SECTION 3

DEPARTMENT OF COMMERCE WEATHER PROGRAMS
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

The National Oceanic and Atmospheric Administration (NOAA) is the principal meteorological agency of the Federal government. By law, NOAA is responsible for reporting the weather of the United States, providing weather and flood warnings and forecasts to the general public, developing and furnishing applied weather services, and recording the climate of the United States. This mission is carried out within NOAA by the National Weather Service (NWS); the National Environmental Satellite, Data, and Information Service (NESDIS); the Office of Oceanic and Atmospheric Research (OAR); the National Ocean Service (NOS); and the NOAA Marine and Aviation Operations (NMAO).

NATIONAL WEATHER SERVICE

NOAA's National Weather Service (NWS) has the principal responsibility for planning and operating the basic climate, hydrologic, and weather services and certain specific applied services. The NWS provides climate, water, and weather warnings and forecasts for the U.S., it's territories, adjacent waters, and ocean areas to help protect life and property and enhance the national economy. NWS data and products form a national information data base and infrastructure which can be used by other governmental agencies, the private sector, the public, and the global community. In support of this mission, NWS:

- Issues warnings and forecasts of weather, flood, Great Lakes, coastal and ocean conditions.
- Observes and reports the weather and the river and ocean conditions of the U.S. and it's possessions.
- Develops and operates national meteorological, hydrological, climate, space weather and oceanic service systems.
- Performs applied meteorological, hydrological, space environmental and climate research.
- Assists in developing community awareness and educational materials and programs concerning weather-related natural disasters.
- Participates in international hydrometeorological and space weather activities, including the exchange, coding and monitoring of data and forecasts, and also including the installation and repair of hydrometeorological equipment and systems overseas under the Voluntary Cooperation Program.

The basic enabling legislation and authority for weather services are summarized as follows:

- Organic Act of 1890 created the United States Weather Bureau in the Department of Agriculture.
- Enabling Act of 1919 allowed the United States Weather Bureau to enter into cooperative agreements for providing agriculture weather services.
- Flood Control Act of 1938 authorized the establishment, operation, and maintenance of the Hydroclimatic Network by the Weather Bureau for Flood Control; on July 1, 1940, the Weather Bureau was transferred from the Department of Agriculture to the Department of Commerce.
- Federal Aviation Act of 1958 outlined duties of the Secretary of Commerce for providing weather observations and services to aviation.
- Reorganization Plan 2 of 1965 placed the "National Weather Service" in the newly created Environmental Science Services Administration (ESSA).
- Reorganization Plan 4 of 1970 made the NWS a part of the newly created National Oceanic and Atmospheric Administration (NOAA).
- International Convention for the Safety of Life at Sea (SOLAS) agreement to which the U.S. is signatory. This sets international policy for safer shipping and cleaner seas. The U.S implements the convention through Executive Order 12234 of Sept. 3, 1980 -- Enforcement of the Convention for SOLAS. Among the obligations of the agreement is to provide meteorological warnings and forecasts to ships at sea using charts and radio messages.

SERVICES

NWS provides climate, water, weather and space weather prediction services; including watches, warnings, advisories, and forecasts 24 hours a day, seven days a week. These services are provided through a national network of 122 Weather Forecast Offices (WFOs), 13 River Forecast Centers (RFCs), and the nine centers of the National Centers for Environmental Prediction (NCEP).

These offices collect data, prepare local warnings and forecasts, and disseminate information to the public both nationally and internationally through NOAA Weather Radio, satellite-based telecommunication systems, radiofacsimile, the media and the internet. Forecast and warning services prepared at WFOs are derived in part from prediction guidance prepared by the 13 RFCs and the nine NCEP cen-

ters. These centers are the Hydrometeorological Prediction Center, Storm Prediction Center, Aviation Weather Center, Environmental Modeling Center, Tropical Prediction Center, Climate Prediction Center, Space Environment Center, Ocean Prediction Center, and NCEP Central Operations.

Continually improving the accuracy, timeliness, and accessibility to prediction services is largely a result of research and development both within the NWS and externally from universities and private corporations.

PUBLIC WEATHER SERVICES.

NOAA's NWS Public Weather Service Program provides forecast, warning, and response services to the public, private meteorological firms, broadcast meteorologists, and NWS partners who are responsible for public safety. These partners include Federal, state, and local emergency managers and planners. NWS forecasters use their expertise to routinely modify a local digital database and issue forecasts for every location in the Nation for sky cover, maximum and minimum temperature, wind speed and direction, precipitation, and hazardous weather information at least two times per day.

The digital forecast information is delivered in a variety of formats (e.g., gridded binary format (GRIB2) via anonymous file transfer protocol, eXtensible Markup Language (XML), text, tabular, graphics) to meet customer and partner needs. NWS forecasters issue short-duration watches and warnings for severe weather, such as tornadoes and severe thunderstorms, as well as long-duration watches, warnings, and advisories for hazardous winter weather conditions, high wind events, dense fog, and temperature extremes. NWS forecasters support several health related programs such as Air Quality, Heat Health, and the Ultraviolet (UV) Index. Ground based ozone concentration forecasts are now being produced for the northeast U.S. and a nationwide development effort is underway. An experimental Heat Health Watch Warning System (HHWWS) has been developed for select cities to provide advance notice of excessive heat events. Also, a climatological approach to providing UV alerts for the entire nation is under development.

The NWS Public Weather Service Branch serves as the primary focal point for collaboration with Federal transportation agencies on weather issues related to surface transportation; with federal and private entities on the Ultra-Violet index program, and with the World Meteorological Organization on the provision of public weather services to the international community. Additionally, NWS forecasters provide meteorological support both on-site and from WFOs for terrorist acts and other homeland security concerns, as well as accidental releases/spills of hazardous chemical, biological, or radioactive materials.

In 2005, the NWS began creating, and making readily available, operational forecasts in digital formats. This information is stored in the National Digital Forecast Database NDFD). Output from NDFD is available in the form of web graphics available over the Internet, in GRIB2 format (GRIB2) via anonymous file transfer protocol, or in XML via an experimental web service. NDFD data can also be converted to a file format that can be used with Geographical Information System (GIS) software. NDFD includes various sensible weather elements such as temperature, probability of precipitation, weather and sky cover; and also includes derived elements such as relative humidity and apparent temperature (i.e., wind chill and heat index). For more detailed information on NDFD, please see http://www.nws.noaa.gov/ndfd/.

AVIATION WEATHER SERVICES.

The NWS provides a broad range of services in support of the aviation community. The WFOs prepare Terminal Aerodrome Forecasts (TAFs) four times a day, with amendments as needed, for more than 590 public-use airports in the U.S. and it's territories in the Caribbean and Pacific. These offices also produce about 241 individual route-oriented forecasts three times a day for the 48 contiguous states and over the Pacific Ocean.

NCEP's Aviation Weather Center (AWC) and the Alaska Region's Alaska Aviation Weather Unit (AAWU), and WFO Honolulu, HI prepare area forecasts three or four times daily describing general aviation weather conditions over the lower 48 states, the Gulf of Mexico, Caribbean, Alaska, Hawaii and coastal waters respectively. These three specialized offices also issue in-flight advisories and warnings of hazardous weather conditions associated with thunderstorms, icing, turbulence, and strong, low level winds. The AWC also prepares forecasts of significant aviation weather over the continental U.S. four times a day for flight levels from the surface to 25,000 feet.

NWS Center Weather Service Units located in each of the 21 FAA Air Route Traffic Control Centers provide direct meteorological support to enroute centers, Terminal Radar Approach Controls, airport towers, and Automated Flight Service Stations.

The NWS provides a service to international aviation as one of the International Civil Aviation Organization's (ICAO's) two World Area Forecast Centers. NCEP's Environmental Modeling Center supplies global gridded model data of temperature, winds, and humidity twice a day for flight levels from 5,000 to 45,000 feet. The AWC prepares forecasts four times a day of globally significant thunderstorms, tropical cyclones, severe squall lines, moderate or severe turbulence and icing, and cumulonimbus cloud associated with the above, from 25,000 to 63,000 feet. The forecast charts also

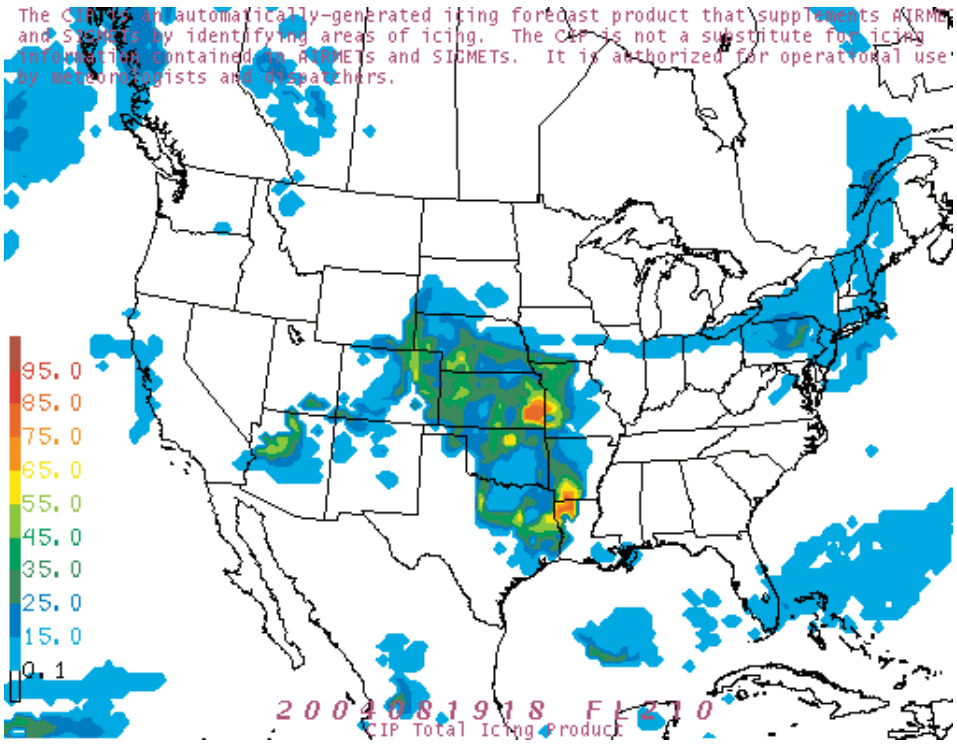


Figure 3-DOC-1. Current Icing Potential (CIP) Product. The FAA's Aviation Weather Research Program and the NWS developed this graphical icing product, updated every 3 hours, and available for user selected altitudes across the contiguous U.S.

include information on volcanoes, radiological releases, jet streams and tropopause heights. This information is transmitted by the International Satellite Communications System with coverage in the Americas, Caribbean, western portions of Europe, the Pacific, and eastern Asia.

Within the framework of the international airways volcano watch, the NWS and NCEP share management responsibility for operating the Volcanic Ash Advisory Centers (VACC) in the state of Washington and Anchorage, Alaska.

The NWS, working closely with the FAA's Aviation Weather Research Program, developed new experimental and operational forecast products designed to improve aviation hazard forecasts from zero to six hours into the future (Figure 3-DOC-1).

New icing and turbulence products for meteorologists and end users became operational in FY 2004. Improved software tools to increase the number of terminal airports covered by a forecast are also under development.

MARINE WEATHER SERVICES.

The NWS Marine Weather Program is the lead for the nation's marine and coastal weather services. Programs include warnings, forecasts, and advisories for coastal waters, offshore, high seas, and near-shore and open waters of the Great Lakes. It leads programs for tropical cyclone, coastal flood, severe convective coastal weather, and coastal hazards such as high surf, rip currents, and tsunamis. NWS forecasters at 46 coastal and marine WFOs, in collaboration with NCEP's Ocean Prediction Center and Tropical Prediction Center, provide a range of weather services focused on the expanding and weather-sensitive U.S. coastal population and those responsible for its safety.

The program develops plans, policy and procedures for the delivery of marine and coastal weather products and services from the coastal WFOs, the Ocean Prediction Center, the Tropical Prediction Center, and the Central Pacific Hurricane Center. It ensures marine and coastal forecast training needs are met. The program works with the NWS's Office of Science and Technology to prioritize tropical, marine and coastal science and technology development and approve new or improved product designs, and with the Office of Operational Systems to ensure the collection of marine and coastal observations and the delivery of marine and coastal products to users. The program creates internal and external partnerships, collects and validates marine and coastal service and mission needs, solicits feedback on products and services and validates whether these needs are met.

The program works with:

- NOAA's NESDIS, the U.S. Navy and the U.S. Coast Guard (USCG) to provide ice warning and advisory services through the joint National Ice Center;
- the Navy, the USCG, the U.S. Maritime Administration, and the Corps of Engineers to safely operate the nation's Marine Transportation System;
- the Department of Defense, Federal Emergency Management Agency, and Corps of Engineers to provide tropical cyclone services;
- the USCG, Navy, Air Force, and private entities to disseminate weather to mariners;
- NOAA's National Ocean Service (NOS) on the PORTS and TIDES programs; and
- the World Meteorological Organization to provide services to the international community.

It also works in cooperation with NOAA's Office of Response and Restoration, the Department of Defense, and Department of Homeland Security for forecasting services for hazardous material spills, marine area search, rescue, and recovery operations, and security needs.

FIRE/ALL HAZARD WEATHER SERVICES.

NOAA's NWS offices provide routine pre-suppression and wildfire weather support to Federal and state land management agencies. NWS forecasters provide routine fire weather forecasts, forecast support for the National Fire Danger Rating System, and site specific forecasts during the local fire season over roughly three-quarters of the Nation.

The NWS deploys a national cadre of specially-trained Incident Meteorologists (IMETs) to large wildfires and coordination centers for on-site weather support. IMETs use weather instrumentation, telecommunications, and display equipment to aid in on-site forecast preparation and briefings.

In the early morning, NOAA's National Centers for Environmental Prediction's Storm Prediction Center issues one and two-day fire weather outlooks that highlight areas with critical and extremely critical fire potential based on the state of the fuels (trees, brush, grasses), and critical weather parameters. Areas where significant lightning activity accompanied by less than 0.1 inch of precipitation (dry lightning) is forecast are also highlighted. Additionally, NWS forecasters provide forecasts in response to hazardous material incidents or Incidents of National Significance (such as the Columbia Recovery effort)

TSUNAMI WARNINGS.

Tsunami watches, warnings, and information bulletins for the Pacific Ocean and Hawaii are prepared by the Richard H. Hagemeyer Pacific Tsunami Warning Center in Ewa Beach, Hawaii, and for west coast of the continental U.S. and Alaska by the West Coast/Alaska Tsunami Warning Center in Palmer, Alaska. NWS collects and analyzes observational data from an international network of seismological observatories, sea-level observing stations, and deep-ocean tsunami detection buoys which operate on a cooperative basis. The centers use these data to prepare and disseminate watches, warnings, and information bulletins to international customers, WFOs, federal and state disaster agencies, military organizations, private broadcast media, and other agencies involved with warning the public.

CLIMATE SERVICES (CS).

Climate prediction products and other services relate to the period of week two out to one year, including seasonal forecasts and hazard assessments. The NWS's Climate Prediction Center produces a suite of products covering these periods. The climate services program provides the strategic vision for climate services at NWS, oversees the program including the expanded regional and local climate services programs, and serves as steward of the climate observing system. It maintains strong ties with other countries; across NOAA lines, specifically through the NOAA Climate Office; with Federal agencies; the university community; and the private sector and encourages collaborative arrangements among the Regional Climate Centers (managed by NOAA/NESDIS), the State Climatologists, and NWS WFOs and regional headquarters to tailor climate forecasts for local users.

HYDROLOGIC SERVICES.

The 122 WFOs, 13 River Forecast Centers (RFCs), and NCEP's Hydrometeorological Prediction Center (HPC) work as a team to provide hydrologic forecast and warning services which minimize loss of life and property damage from flooding and to meet the water service needs of our Nation. RFC hydrologists use a modeling system called the NWS River Forecast System (NWSRFS) to produce forecast time series of discharges or river stages at approximately 4,000 locations along the nation's rivers. HPC provides the quantitative precipitation forecasts serving as the primary forecast input for NWSRFS. RFCs also provide long-term water supply forecasts used by water managers in the western U.S., where decisions about water allocation and use are particularly critical now, with much of the West still feeling the effects of a long-term drought.

WFOs work cooperatively with the RFCs to monitor the major river systems around the clock. Using RFC guidance, advanced Doppler radar (NEXRAD) and telemetered rain gauge observations, WFOs continuously monitor the threat of flash flooding and urban flooding to provide timely flood watches and warnings to protect life and property.

Partnerships with a variety of Federal, state and local agencies are critical to NOAA's NWS Hydrologic Services Program. For example, the NWS works very closely with the United States Geological Service (USGS), the United States Army Corps of Engineers, the Natural Resources Conservation Service (NRCS), the Bureau of Reclamation, and the Bureau of Land Management on a variety of water related issues including stream gauging, support of flood fighting activities, river and water supply forecasting, and water management. River stage observations and stage-discharge relationships provided by the USGS are critical to warning and forecast operations for the Nation's rivers. The NRCS furnishes snow measurements that are combined with advanced snow modeling and analysis provided by NOAA's National Operational Hydrologic Remote Sensing Center to support joint NWS-NRCS water supply forecasting in the western U.S.

The NWS is implementing the Advanced Hydrologic Prediction Service (AHPS) to provide hydrologic forecasts with lead times ranging from days to months. AHPS builds on the existing NWS infrastructure, including AWIPS, NEXRAD, and NWSRFS.

AHPS also provides Ensemble Streamflow Prediction, a feature that allows the NWS to quantify forecast uncertainty. This lets decision makers apply risk-based analyses as they respond to flooding, and as they try to balance competing demands on water supply, especially during periods of drought.

Flash floods, typically caused by intense, small-scale convection, are the leading cause of flood fatalities. Another AHPS capability, known as Flash Flood Monitoring and Prediction (FFMP), combines high-resolution radar rainfall observations with Geographic Information System (GIS) technology to provide more accurate and much more precise flash flood forecasts. The added precision provided by FFMP greatly reduces the false alarm rate of flash flood forecasts, making them more credible and leading to better public response, which will ultimately save lives.

AHPS services are provided as a suite of Web-based products (weather.gov/water), that feature user-friendly menus and maps which allow users to zoom in to areas of interest. Clicking on an area of interest on the national map (Figure 3-DOC-2) brings the user to a map of the NWS WFO serving that area which provides more detailed information on river conditions.

AHPS also opens opportunities to improve NOAA's analysis and forecast capabilities related to coastal water conditions, through joint efforts with other components of NOAA (e.g., National Ocean Service, Office of Oceanic and Atmospheric Research).

OBSERVATIONS.

Observations form the basis for forecasts and the monitoring and evaluation of the environment. Differing applications and requirements are associated with each of these functions. Forecast applications associated with watch and warning functions must be served immediately, while real-time availability is not a significant factor for climate monitoring. The range of differing applications will dictate how future instrument deployments will be conducted. This poses a constant challenge to the optimization of resources placed into in situ and remotely sensed observation platforms.

The fundamental application of observations is to deliver better products and improve services. This demands the link between improved services and observing systems be well defined. We need to determine the gaps in observations to meet varied requirements, emphasizing the importance of metadata and sensor calibration continuity. Coordinated efforts within the Federal community throughout all aspects of observations development, dissemination and use are needed for efficiently utilizing of resources.

The NWS approach for improving observations consists of several efforts:

• Make better use of data from observing systems that currently exist;

• Extend the system life of current observing systems to postpone technical obsolescence;

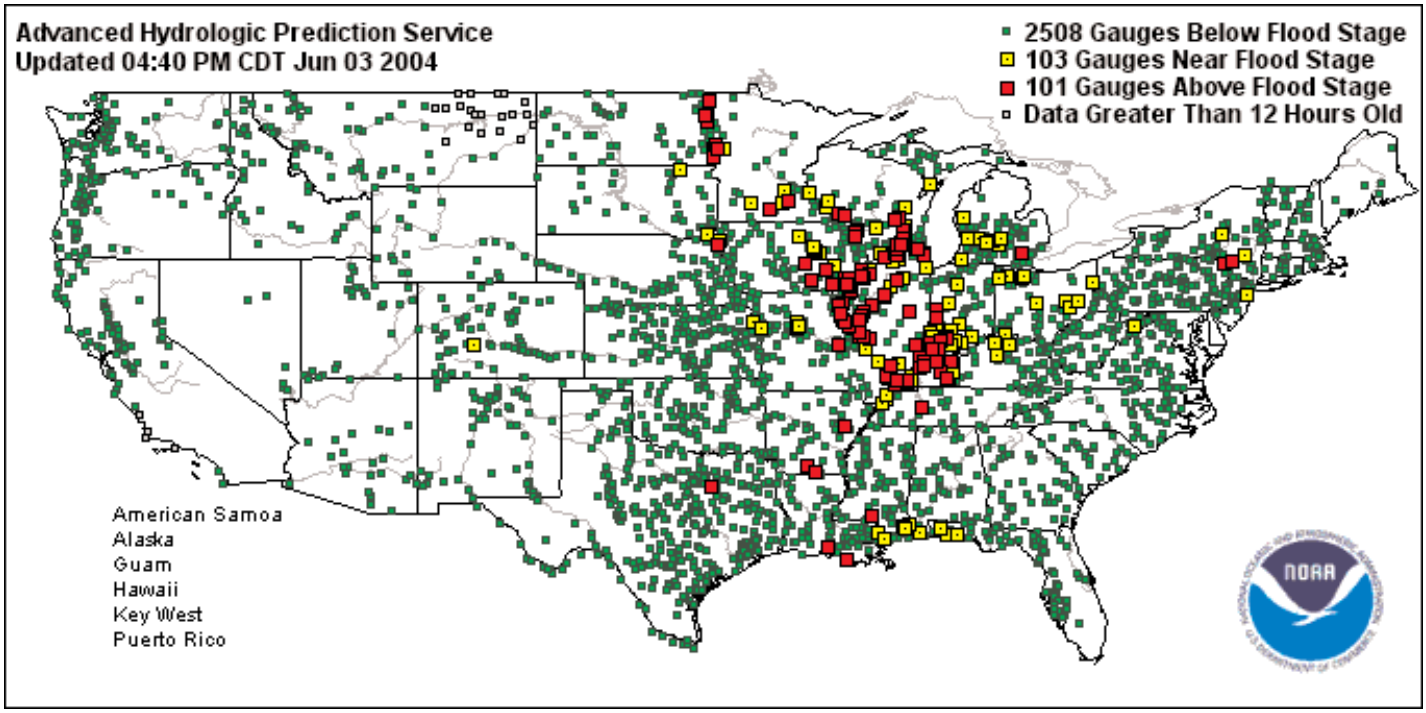


Figure 3-DOC-2. Map showing status of river conditions throughout the Nation. This map is included on the primary AHPS Web page and it provides access to more detailed local information on river conditions, including observations and forecasts at specific locations along rivers, as well as expected impacts that could result from flooding.

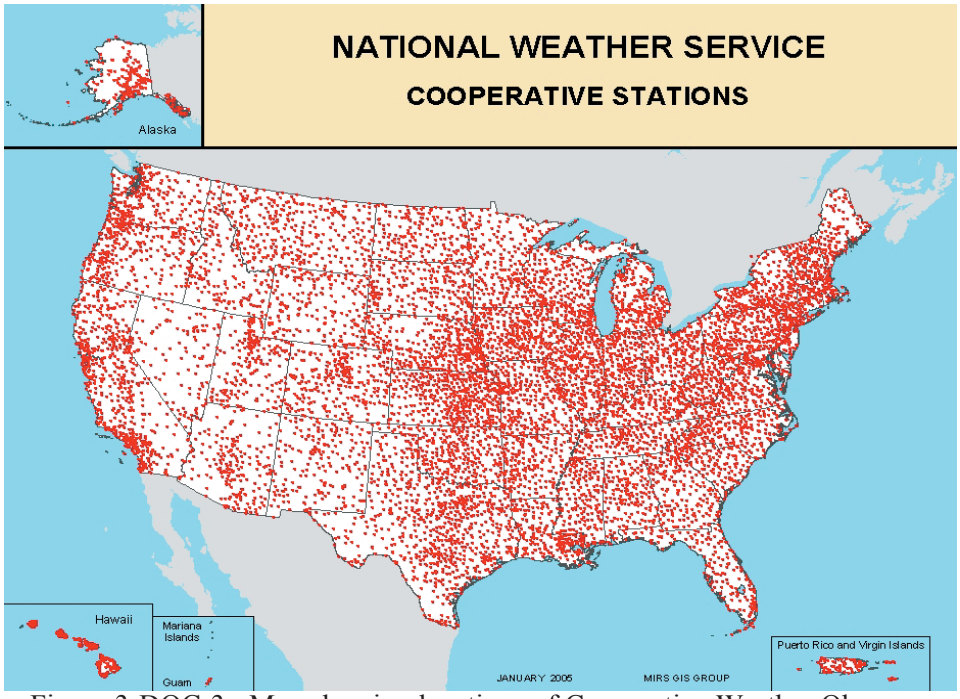


Figure 3-DOC-3. Map showing locations of Cooperative Weather Observer Network (COOP). Interactive web site can be found at *http://www.nws.noaa.gov/om/coop/wfo-rfcmap.htm*

• Replace obsolete observing systems;

• Implement new observing technologies and communication systems that better meet the data needs of our customers; and

• Strengthen the link between user requirements and technology research and development.

The NWS manages programs that produce observations in support of a wide range of customers, such as the aviation, climate monitoring and research communities. As part of its responsibility, the NWS inspects all surface weather observing stations and certifies equipment and observers. NWS Headquarters establishes policy for observations and standards and coordinates with other Government agencies and international organizations.

NOAA's Cooperative Weather Observer Network (COOP) is the Nation's largest and oldest weather network (Figure 3-DOC-3). Modernization of the COOP under NOAA's Environmental Real-Time Observation Network (NERON) is consistent with the President's Climate Change Research Initiative, providing a richer source of data to improve weather, water and climate forecasting and to contribute to climate change research. The COOP is the primary source for monitoring U.S. climate variability over weekly to interannual time frames. These data are also the primary basis for assessments of century-scale climate change. The modernized network will add to NOAA's vision of an-end-to-end monitoring program that "takes the temperature" of the earth's systems.

NATIONAL CENTERS FOR ENVIRONMENTAL PREDICTION (NCEP).

NCEP delivers analyses, guidance, forecasts and warnings for weather, ocean, climate, water, land surface and space weather to the Nation and world. NCEP provides science-based products and services through collaboration with partners and users to protect life and property, enhance the Nation's economy and support the Nation's growing need for environmental information. Each service center depends on the observational infrastructure, the data assimilation systems, the numeric modeling function, and the application of model output statistics to produce value added forecast guidance products for NWS field offices and other users.

NCEP is organized into seven science-based, service-oriented centers that generate environmental prediction products and two central support centers that develop and operate numerical models -- the basis for NWS predictions.

Storm Prediction Center.

The Storm Prediction Center (SPC) focuses on hazardous weather events, such as severe thunderstorms, tornadoes, extreme winter weather, and excessive precipitation with emphasis on the first few hours of the forecast period. All Tornado and Severe Thunderstorm Watches issued anywhere in the contiguous U.S. come from the SPC. Also, the SPC prepares Mesoscale Discussions which are technical discussions of developing mesoscale features and their impact on hazardous weather. For longer time periods, the SPC produces the Convective Outlook which are one, two and three-day forecasts of the probability and intensity of both non-severe and severe thunderstorms (including tornadoes). The SPC also issues one and two-day National outlooks for areas with critical and extremely critical fire potential out to two days.

Hydrometeorological Prediction Center.

The Hydrometeorological Prediction Center (HPC) provides forecast, guidance, and analysis products and services (1) to support the daily public forecasting activities of the NWS and its customers, and (2) to provide tailored support to other government agencies in emergency and special situations. As part of this mission, HPC prepares Quantitative Precipitation Forecasts (QPF) used by the RFCs to

develop local river and flood forecasts and by WFOs to develop local rainfall, snow and ice forecasts. The HPC provides special QPFs and coordinates with other Federal agencies, such as the Federal Emergency Management Agency (FEMA), during major flood events. The HPC also provides an array of analyses and forecasts out to seven days of frontal systems, pressure patterns, temperature, and precipitation for use by WFOs and the private weather community. Additionally, HPC serves as the backup to the National Hurricane Center.

Aviation Weather Center.

The NCEP experts for aviation meteorology are concentrated at the Aviation Weather Center (AWC). The AWC provides weather warnings, advisories and forecasts to the aviation community under an international agreement through the International Civil Aviation Organization. The AWC provides wind, and flight hazards (e.g., icing, turbulence) forecasts for flight planning and en route aircraft operations for the U.S., the Gulf of Mexico, the Caribbean Sea, the Atlantic and Pacific routes in the Northern Hemisphere and some routes in the Southern Hemisphere.

Environmental Modeling Center.

The Environmental Modeling Center (EMC) improves NCEP's numerical climate, water, and weather predictions through data assimilation and computer modeling. To provide mesoscale predictions (thunderstorms, hurricanes, tornadoes, blizzards, etc.), ocean predictions and global weather and climate predictions, EMC develops, adapts, improves, and monitors data assimilation systems and global, regional and mesoscale models of the atmosphere, land surface, ocean, and atmosphere/ocean/land systems.

The EMC uses advanced modeling methods developed internally and cooperatively with universities, the international scientific community, NESDIS, NOAA laboratories, and other government agencies. As an example, EMC is a partner in the NASA/NOAA Joint Center for Satellite Data Assimilation (JCSDA) designed to accelerate the use of research and operational satellite data in NCEP operational models. The EMC integrates research and technology through collaborative model development projects. These interactions serve as an efficient and effective interface between NCEP and the scientific community that develop ideas, numerical models, and forecast techniques to implement model improvements and improve NWS products.

The EMC conducts applied research and technology transfers and publishes research results in various media for dissemination to the world meteorological, oceanographic, and climate community. EMC also participates in ongoing interactive research programs such as the United States Weather Research Program (USWRP) Hurricane at Landfall project and the community Weather Research and Forecast (WRF) model. Furthermore, EMC is participating in the Winter Storm Reconnaissance Program in the Pacific through targeted observations aimed at improving forecasts across the country. EMC efforts with collaborative development have resulted in improvements to mesoscale and global models, as well as advancements in hurricane track forecasts, climate forecasts and air quality forecasts.

Climate Prediction Center.

The Climate Prediction Center (CPC) provides operational monitoring and prediction of global and regional climate variability, with emphasis on applied research and partnerships, to improve understanding of the global climate system, weather and climate links, extremes and trends. CPC develops and maintains data bases for determining current and historical climate anomalies and trends, and provides analyses and assessments of their origins and linkages to the global climate system. CPC products and services cover time scales ranging from next week (days 6-10) to seasons and out to a year in advance, and cover land, ocean, and atmosphere extending into the stratosphere. CPC's products include probabilistic long range outlooks for temperature and precipitation, the multi-agency U.S. Drought Monitor, a drought outlook, and El Niño Southern Oscillation (ENSO) discussions and outlooks, among many others. WFOs, as well as the public, private industry, and the national and international research community use CPC products and climate services.

Space Environment Center.

The Space Environment Center (SEC) provides national and international forecasts, alerts, and warnings of extraordinary conditions in the space environment, solar radio noise, solar energetic particles, solar X-ray radiation, geomagnetic activity, and conditions of stratospheric warming. The SEC observes, assesses, and predicts activity in the space environment to promote public safety and to mitigate economic loss that could result from disruption of satellite operations, communications and navigation systems, and electric power distribution grids.

The SEC issues to the public, its U.S. Air Force partners, and vendors of value-added services specific predictions of the space weather activity level for the next three days and more general predictions up to several weeks in advance, as well as weekly summaries of observed solar terrestrial conditions. SEC serves as the international World Warning Agency for the International Space Environment Service (ISES). It exchanges international data (solar wind, X-ray, sunspot, corona, magnetic, and ionospheric measurements-in real-time) and, from these data, provides and meets additional specific needs of other government agencies. SEC distributes (receives) data to (from) other countries and issues a consensus set of daily

forecasts for international use.

Ocean Prediction Center.

The Ocean Prediction Center (OPC) provides atmospheric and oceanographic warning, forecast, and analysis products and services for the North Atlantic and North Pacific (north of 30 degrees - see Figure 3-DOC-4) as part of the NWS mission of protecting life and property and enhancing economic opportunity. As part of this responsibility, OPC handles U.S. international meteorological obligations to marine interests under the International Convention for Safety of Life at Sea (SOLAS). The OPC provides weather and sea state warnings and forecasts for the offshore waters of the U.S. and the high seas of the Northern Hemisphere north of 30 degrees for planning and operational purposes. OPC warnings and products go directly to ships and are vital for the protection of life and property at sea, and enhancement of the economy. The OPC also coordinates forecasts with and provides forecast guidance to WFOs with coastal responsibilities. The OPC, the Tropical Prediction Center (TPC), HPC, and WFO Honolulu, HI collaborate daily to produce unified and seamless surface weather analyses covering from 30 degrees South to the North Pole, and from East Asia across the Pacific and Atlantic to Western Europe and Africa.

Tropical Prediction Center/National Hurricane Center.

The NCEP experts in the area of tropical meteorology are concentrated in the Tropical Prediction Center (TPC)/National Hurricane Center (NHC). TPC/NHC services include public and marine advisories, watches, and warnings for tropical cyclones in the North Atlantic and eastern North Pacific hurricane basins including the portions of the coastline threatened by such storms. In addition, TPC forecasters provide marine analyses and forecast products for the same areas of responsibility, south of 30 degrees north latitude and a portion of the southeast Pacific. TPC warnings and products go directly to ships and are vital for the protection of life and property at sea, and enhancement of the economy. The TPC/NHC provides guidance, coordination, and tropical weather expertise to WFO forecasters, the media, and private industry.

NCEP Central Operations.

The NCEP Central Operations (NCO) is responsible for NCEP operations, including access to real time data, and its quality control and use in numerical weather prediction systems, as well as the workstations used by NCEP forecasters to access model output and other data necessary for producing guidance products.

The NCO provides management, procurement, development, installation, maintenance, and operation of all computing and communications related services that link individual NCEP activities together. The NCO is the focal point for establishing and executing policies, standards, procedures, and documentation for computing and communications within the entire NCEP organization. The NCO maintains and manages the supercomputer and runs the computer applications that generate all NCEP model products. The NCO leads the technical transition between the research and development of numerical weather and climate prediction models and their operational use on the NCEP computer systems.

In addition, NCO provides 24-hour information services and operational support for NCEP computing systems, including the network which ties together internal NCEP communications, NWS high performance computer systems, forecaster workstations, personal computers and a user service that support all NCEP centers. Since an upgrade to NCEP's main computer systems and facilities in 1999, and throughout subsequent upgrades, NCO has delivered NCEP model forecasts and products to its users with a high degree of reliability and timeliness.

Other NWS Offices with National Responsibilities.

In addition to the NCEP centers, there are two other offices that provide National products. They are the Alaska Aviation Weather Unit and the WFO Honolulu/Central Pacific Hurricane Center.

• Alaska Aviation Weather Unit. The Alaska Aviation Unit (AAWU)

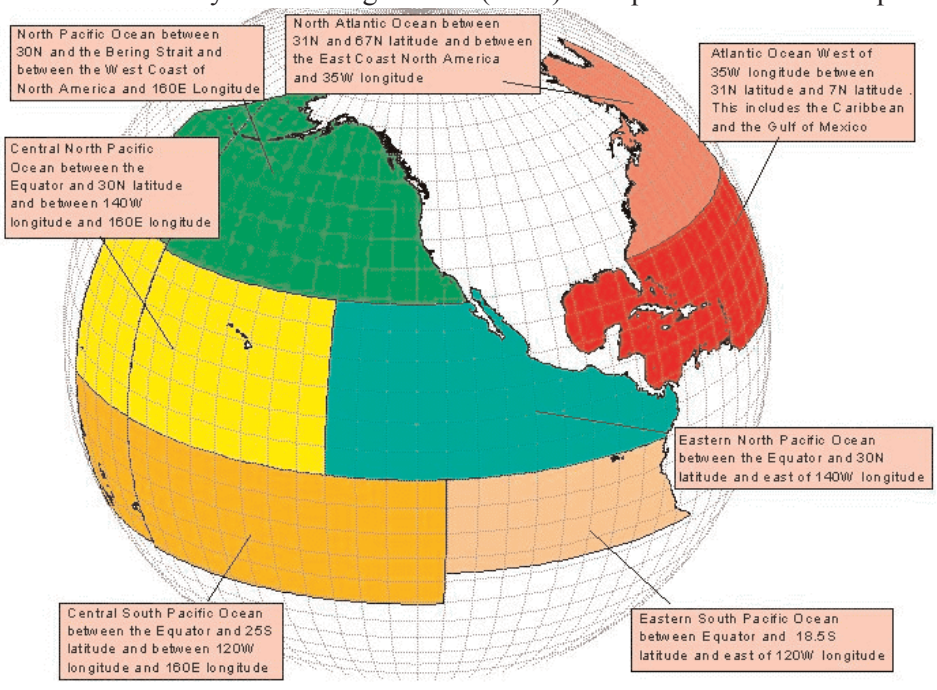


Figure 3-DOC-4. United States High Seas Forecast Areas of Responsibility.

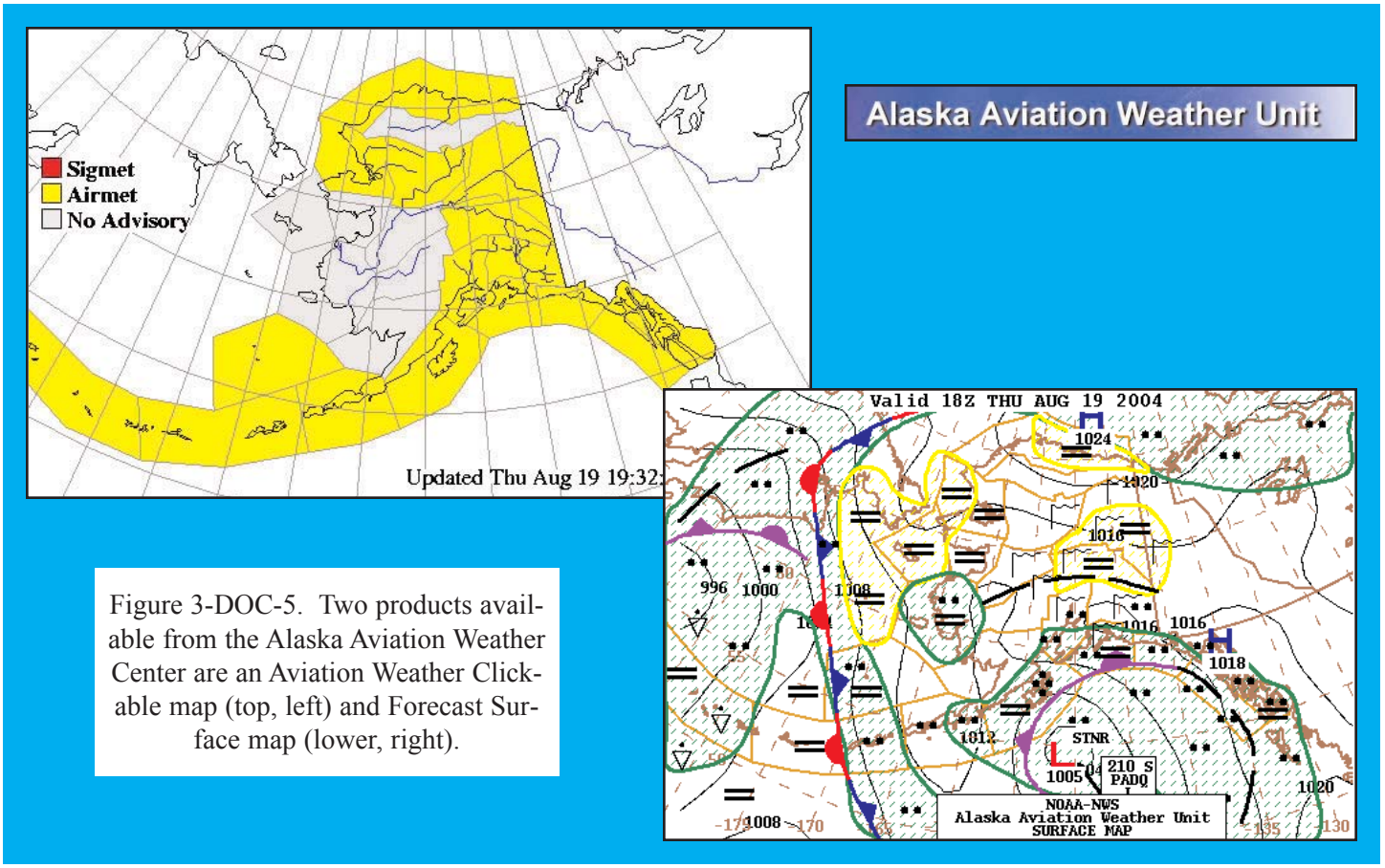


Figure 3-DOC-5. Two products available from the Alaska Aviation Weather Center are an Aviation Weather Clickable map (top, left) and Forecast Surface map (lower, right).

provides wind, temperature, and flight hazards (e.g., icing, turbulence) forecasts for flight planning and enroute aircraft operations for Alaska and surrounding areas (Figure 3-DOC-5).

• WFO Honolulu/Central Pacific Hurricane Center. WFO Honolulu/Central Pacific Hurricane Center (CPHC) provides products in aviation, marine, and tropical cyclone areas. In aviation, WFO Honolulu provides wind, temperature, and flight hazards (e.g., icing, turbulence) forecasts for flight planning and enroute aircraft operations for the central north Pacific from 140 degrees W to 160 degrees E longitude and in the Oakland Flight Information Region south of 30 degrees N latitude through ICAO international agreement. The office handles international meteorological obligations to marine interests under the International Convention for Safety of Life at Sea (SOLAS). WFO Honolulu provides weather and sea state warnings and forecasts for the high seas of the central north and south Pacific south of 30 degrees N latitude. CPHC issues tropical cyclone advisories, forecasts, watches, and warnings for the central north Pacific including Hawaii.

SUPPORTING RESEARCH

The NWS conducts applied research, building upon the more basic research conducted by NOAA laboratories and the academic community. Applied meteorological and hydrological research is integral to providing more timely and accurate weather, water, and climate services to the public.

METEOROLOGICAL RESEARCH.

The NWS conducts meteorological research to develop, test, evaluate, and improve numerical models and analysis/forecast techniques for weather and climate prediction including:

• Techniques for predicting mesoscale phenomena (e.g., heavy precipitation, tornadoes, and severe thunderstorms).

• Models to improve hurricane tracking, hurricane probability estimates, and tropical analyses.

• Storm surge models to assist in developing hurricane evacuation plans for additional coastal basins.

• Techniques to improve prediction of seasonal to interannual climate variability and their impacts on weather variability.

HYDROLOGIC RESEARCH.

The NWS develops, implements and operationally supports improved hydrologic, hydraulic and hydrometeorological models and manages hydrologic data and enhanced quality control procedure to support national flood and water resources forecasting. Research encompasses the following areas:

• Improvements to the Ensemble Streamflow Prediction (ESP) system and its complementary models in the NWS River Forecasting System. Research, development and implementation of improved ESP procedures which improve forecast accuracy and

quantify uncertainty at all time scales.

• Specialized flood and flash flood forecasting procedures using linked hydrologic, hydraulic and meteorological models. Major research areas include developing distributed hydrologic models that use high resolution precipitation data from the NWS radar network, improvement of cold region processes in watershed models, and assimilation of data to improve initial conditions. Highly specialized hydraulic models for routing river flows will also provide information for generating maps of inundated areas.

• Development of improved multisensor precipitation estimates for input estimates for input into operational hydrologic and atmospheric models. Radar, rain gauge and satellite rainfall estimates are merged to produce optimum rainfall analyses.

• Development of verification methods to assess the added-value of new science and technology to the customer.

SPACE WEATHER RESEARCH.

Research and development at SEC emphasizes understanding of the fundamental physical processes governing the regime from the solar surface, through the interplanetary medium, into the magnetospheric-ionospheric regions, and ending in Earth's upper atmosphere. These processes are manifest in the climatology and disturbances of Earth's magnetic field, the ionosphere, the charged particle populations at satellite orbits, and the atmospheric density at high altitudes (including low-Earth orbit). This applied research is focused on areas where advanced applications can be devised and prototyped to improve the specification and forecast of conditions in the space environment by developing and implementing models and indices, as well as by obtaining and processing new observations.

• Developing of the first dynamic, global ionospheric model to use ensemble Kalman filter techniques to assimilate data every 15 minutes. Disparate data from widely dispersed sources will enable the model output to be useful to radio-communicators and Global Positioning System (GPS) and Loran users.

• Developing of models to characterize and predict geomagnetic storm intensity development, spatially and temporally.

SUPPORT FOR COLLABORATIVE RESEARCH WITH THE ACADEMIC COMMUNITY AND OTHER PARTNERS.

The Collaborative Science, Technology, and Applied Research (CSTAR) program was established to bring NWS-supported collaborative activities with the academic community into a structured program and to create a cost-effective transition from basic and applied research to operations and services. The CSTAR Program issues requests for proposals through which colleges and universities compete for 1-3 years of research funding. CSTAR supports shorter-term research activities with colleges and universities through the NWS/Cooperative Program for Operational Meteorology, Education, and Training (COMET) Outreach Program. The NWS also funds specific applied research grants and cooperative agreements directly in support of hydrology and meteorology research needs.

TRAINING.

NOAA's NWS provides training to its work force to enhance the professional and scientific development of its staff in support of NOAA's NWS mission and strategic goals. Training deficiencies and requirements are identified and addressed via the National Strategic Training and Education Plan (NSTEP) process, described in NWS Instruction 20-102 and available at http://www.nws.noaa.gov/directives/020/pd02001002a.pdf.

Training is provided through a variety of in-residence courses and distance learning techniques. Hands-on, in-residence training can be acquired at any of the three NOAA's NWS professional training facilities. The NWS Training Center (NWSTC) in Kansas City, Missouri, provides technical, meteorological and hydrologic, and management/leadership training. The Warning Decision Training Branch (WDTB) in Norman, Oklahoma, conducts situational awareness and remote sensing training with modules that integrate data for improving the warning decision process.

Finally, the Cooperative Program for Operational Meteorology, Education and Training (COMET) in Boulder, Colorado, offers advanced meteorological and hydrometeorological education to ensure that NWS employees have access to the latest software, hardware to improve forecasting techniques. All three facilities also offer distance learning, Internet modules, teletraining, webcasts and CD-ROM based training. NWS employees have direct access to scientific and managerial training materials through the DOC/NOAA Learning Management System (LMS).

The NWSTC, is also working to expand its leadership training and development skills through NOAA's NWS Leadership Academy. The goal of the Leadership Academy is to enable NWS and NOAA employees to become world-class leaders. The Academy is built on a sequential and progressive design to help develop employee professional skills and capabilities to improve employee performance. From entry into the agency to senior career status, employees can take advantage of courses and processes that are part of a powerful management and leadership learning environment. Finally, NWS is working to develop an organized curriculum to supply the necessary knowledge, skills, and abilities for all positions.

The National Environmental Satellite, Data, and Information Service (NESDIS), part of the National Oceanic and Atmospheric Administration (NOAA), manages the U.S. civil operational environmental satellite systems, as well as the three NOAA National Data Centers (NNDCs) that develop global, national, and regional databases that support meteorology, oceanography, geophysics, and the space environment. From these sources, NESDIS develops and distributes environmental data and information products and services critical to the protection of life and property, the national economy, energy development and distribution, global food supplies, and development and management of environmental resources.

NESDIS was established as a NOAA line office on December 1, 1982. The merger of the former National Environmental Satellite Service (NESS) and the Environmental Data and Information Service (EDIS) formed NESDIS.

NESDIS procures, launches and operates two types of satellites to provide worldwide environmental data and information products and services to Federal agencies, state and local governments, and private users. These are the Polar Operational Environmental Satellite (POES) and Geostationary Operational Environ-mental Satellites (GOES).

Currently NESDIS is operating six polar orbiters. NOAA-17 and NOAA-18 are classified as the primary "operational" satellites and are part of the new series of polar orbiters, with improved sensors, that began with the launch of NOAA-15 in May 1998, followed by NOAA-16 on September 21, 2000, NOAA-17 on June 24, 2002, and finally, the newest, NOAA-18 on May 20, 2005. The NOAA-12, NOAA-14 and NOAA-15 satellites continue to transmit data as stand-by satellites. NOAA-16 will soon also join the ranks as a stand-by, with the successful check-out of NOAA 18. NOAA-17 serves as the primary morning satellite and NOAA-18 the primary afternoon satellite. The POES satellites are constantly circling the Earth in an almost

north-south orbit, passing close to both poles. The orbits are circular, with an altitude between 830 (morning orbit) and 870 (afternoon orbit) km, and are sun synchronous. One satellite crosses the equator at 10:00 a.m. local time, the other at 2:00 p.m. local time. The circular orbit permits uniform data acquisition by the satellite and efficient control of the satellite by the NOAA Command and Data Acquisition (CDA) stations located near Fairbanks, Alaska, and Wallops Island, Virginia. Operating as a pair, these satellites ensure that data for any region of the Earth are no more than six hours old. Each satellite orbits the Earth 14 times per day, collecting global data for atmospheric and surface measurements in support of short-term weather forecasting and longer-term global climate change research. NOAA also manages the command, control, and communications function of the Department of Defense's (DOD's) Defense Meteorological Satellite Program (DMSP) constellations.

An agreement with the European Organization for the Exploitation of Meteorological Satellites (EUMETSAT) gives EUMETSAT responsibility for the morning segment of the polar environmental mission (circa 9:30 a.m. LST), with U.S.-provided payload instruments and sensors, beginning in 2006. Thus, upon inception of this operational arrangement, NOAA will operate the afternoon mission while EUMETSAT will support the morning mission. Under this joint mission, upgraded instruments will be flown that will result in improvements for the user community. For example, the High Resolution Infrared Sounder (HIRS) instrument will be upgraded resulting in improved atmospheric sounding information. The Advanced Very High Resolution Radiometer (AVHRR) global one-kilometer data will be available enhancing the usefulness of this data for fire detection, CoastWatch, and any other applications that require higher resolution. It also provides the opportunity to use new sensor data from EUMETSAT instruments, in preparation for future NPOESS support.

On October 3, 1994, NOAA, DOD, and the National Aeronautics and Space Administration (NASA) combined the nation's military and civilian environmental satellite programs to create an Integrated Program Office (IPO) to develop, manage, acquire, and operate the national polar-orbiting meteorological satellite system, subsequently designated the National Polar-orbiting Operational Environmental Satellite System (NPOESS). The IPO is organizationally located within NOAA and is headed by a System Pro-

gram Director responsible to the NPOESS Executive Committee. This committee, which consists of the Under Secretary of Commerce for Oceans and Atmosphere, the Under Secretary of the Air Force, and the NASA Deputy Administrator, serves as a board of directors to ensure that overall program plans also meet the individual needs of the three participating agencies.

The IPO concept provides each of the participating agencies with lead responsibility for one of three primary functional areas. NOAA has overall responsibility for the converged system and is responsible to the IPO for satellite operations. NOAA is also the primary interface with the international and civil user communities. DOD is responsible to support the IPO for major systems acquisitions including launch support. NASA has a primary responsibility for facilitating the development and incorporation of new cost-effective technologies into the converged system. Although each agency provides certain key personnel in their lead role, each functional division is staffed by tri-agency work teams to maintain the integrated approach. The first operational satellite and ground system will be delivered by the shared system performance prime contractor, Northrop Grumman, and is expected to be available late in this decade depending on when the current U. S. polar satellite assets are exhausted.

NPOESS will provide standard meteorological, oceanographic, environmental, climatic, space environmental remote sensing information, as well as continue providing surface data collection and search and rescue capability. The IPO, in consultation with NOAA and DMSP program offices, is also studying additional potential cost effective approaches to maximize user satisfaction during the transition to NPOESS while guaranteeing continued non-interrupted data services.

The first NPOESS launch is planned for 2009. However, the NPOESS system is a launch-on-demand system. Based on this strategy, the first NPOESS satellite, referred to as C1, should be available in 2008 to support any potential on-orbit or launch failure of existing U.S. polar satellites. However, based on the latest revisions, the new launch date for C1 is November 2009 (See Table 3.1).

NESDIS is also responsible for operating two Geostationary Operational Environmental Satellites (GOES), referred to as GOES East and GOES West. Each satellite views nearly one third of the Earth's surface. The GOES-12 (East) satellite is positioned at 75 degrees W longitude and the equator and monitors North and South America and most of the Atlantic Ocean. The GOES-10 (West) satellite is positioned at 135 degrees W longitude at the equator and monitors North America and the Pacific Ocean basin. The two operate together to provide the kind of continuous monitoring necessary for effective and extensive data analyses. GOES East and West circle the Earth in a geosynchronous orbit, which means they orbit the equatorial plane of the Earth at a speed matching the Earth's rotation. This allows them to hover continuously over one position on the Earth's surface.

The geosynchronous plane is about 35,800 km (22,300 miles) above the Earth, high enough to allow the satellites a full-disc view of the Earth. Because they stay above a fixed spot on the surface, they provide a constant vigil for the atmospheric "triggers" of severe weather conditions such as tornadoes, flash floods, hailstorms, and hurricanes. When these conditions develop, the GOES satellites are able to monitor storm development and track their movements.

Additionally, as part of a NOAA bilateral agreement with Japan, GOES-9 has been provided to the Japanese Meteorological Agency to replace a Japanese geostationary satellite. This will ensure Pacific geostationary satellite coverage for Japan, the U.S. and our allies until the operational readiness of the Japanese Multifunctional Transport Satellite (MTSAT-1R) launched in 2005 is determined. MTSAT-1R will replace GOES-9 as the primary geostationary environmental satellite in the west Pacific region. Finally, GOES-11 is being stored in orbit as a replacement for GOES-12 or GOES-10 in the event of failure of either of these systems.

ENVIRONMENTAL SATELLITE SERVICES

OFFICE OF SATELLITE OPERATIONS.

The Office of Satellite Operations (OSO) directs the operation of NOAA's environmental satellites and the acquisition of remotely sensed environmental data. It manages the Satellite Operations Control Center (SOCC) and Command and Data Acquisition (CDA) stations, which command and control, track, and acquire data from these environmental satellites.

OSO took over the command, control, and communications function of the DOD's DMSP constellation in 1998. The mission of DMSP is to provide meteorological and special sensor data to users in support of worldwide DOD missions. DMSP is now operated from the SOCC at Suitland, Maryland. The SOCC is the primary center for normal operations, mission planning, engineering, launch and early orbit support, and anomaly resolution. A new ground system was developed for DMSP called Integrated Polar Acquisition and Control Subsystem.

OFFICE OF SATELLITE DATA PROCESSING AND DISTRIBUTION.

The Office of Satellite Data Processing and Distribution (OSDPD) directs the operations of NESDIS central ground data processing facilities. It

processes and distributes data from NOAA and non-NOAA environmental satellites and generates automated and interpretive products for various government agencies, private industry and educational institutions. Key customers include the NWS, DOD, FAA, NASA, worldwide Meteorological Watch Offices, EPA and state environmental protection agencies, foreign meteorological agencies, U.S. airlines, universities and private sector companies.

OSDPD exploits data from NOAA polar and geostationary environmental satellites, foreign (European, Japanese, and Indian) operational satellites as well as domestic and foreign research satellites. The latter includes NASA's Tropical Rainfall Measuring Mission (TRMM), QuikSCAT, Earth Observing System satellites (including Aqua, Terra, and Aura missions), Japan's ADEOS-II, and the DOD's WindSAT mission.

OSDPD products are used in real time in the production of forecasts and warnings of severe environmental events such as tornados, thunderstorms, flash floods and hurricanes. Some OSDPD products, such as calibrated radiances from polar orbiting sounders, vertical temperature and moisture profiles, cloud tracked wind speed and direction, and snow cover, are routinely integrated into numerical weather prediction models on a global scale. These products often provide key model input parameters where routine in-situ measurements are not available.

OSDPD satellite products are generated and distributed to a diverse user community for a broad range of environmental applications. The operational satellite data distribution networks provide user access to real-time or near real-time environmental data and information. Quality assurance procedures are used to systematically evaluate and characterize the satellite products and services. This applies to both the fully automated products such as remapped GOES channel imagery and geophysical parameters (e.g., vertical wind profiles, bulk moisture and atmospheric stability indices, etc) and POES-derived parameters (e.g., channel brightness temperatures, precipitation estimates, vegetation indices, sea-surface temperature, temperature and moisture profiles, etc), as well as to the value-added interpretive or analyzed products used to support disaster mitigation and warning services for various Federal agencies and the international community.

The latter category includes products such as tropical storm position and intensity, fire locations and associated smoke areal extent, quantitative precipitation estimates for flash flood warnings, and volcanic ash plume extent and height. OSDPD works closely with its partners in the customer-supplier chain to ensure the most effective and timely implementation of its satellite data products and services. Working with NESDIS research organizations such as The Office of Research and Application (ORA) on the supplier side, and with government (primarily NWS), educational and other organizations on the customer side, new and enhanced product generation algorithms are tested, evaluated, and implemented when deemed sufficiently validated and operationally useful. In partnership with other agencies and internal NESDIS organizations, new technologies are investigated and periodically deployed to satisfy emerging user requirements.

OSDPD distributes these environmental satellite products to the NWS Advanced Weather Interactive Processing System (AWIPS), National Centers for Environmental Prediction (NCEP) and Weather Forecast Offices (WFOs), and other Federal, state, and private sector organizations through dedicated satellite processing and server configurations, or through the NOAAPORT satellite point-to-multipoint broadcast facility. The satellite data and products transmitted via NOAAPORT include remapped imagery, satellite precipitation estimates, high-density wind direction and speed projections at various atmospheric levels, GOES satellite imagery, and volcanic ash advisory messages. Over one hundred universities receive satellite data and products supplied via NOAAPORT. NOAAPORT also delivers GOES and POES products in near real-time to the AWIPS. AWIPS is the NWS display and analysis workstation used in NWS national centers and field sites to integrate and display satellite data, model output, in-situ observations, and radar and wind profiles used in the production of hydrometeorological analyses and forecasts.

In addition, OSDPD serves as NCEP's backup for NOAA GOES data via the Man Computer Interactive Data Access System (McIDAS) and as a primary source to NCEP of NOAA POES and non-NOAA geostationary satellite data. OSDPD also uses various web sites to disseminate satellite data and products. For example, one site (http://www.ssd. noaa.gov) provides information and products on a multitude of OSDPD operational product areas including: worldwide tropical cyclone analyses, volcanic ash analyses, heavy precipitation analyses, snow/ice cover, and smoke and fire analyses. High quality imagery and derived products are extremely popular during hurricane season. Another OSDPD web site (http:// www.osei. noaa.gov) provides satellite imagery of significant environmental events such as oil spills, icebergs, hurricanes, and fires. Satellite data in digital scientific format are also available from ftp://gp16.ssd.nesdis. noaa.gov/ and several data sets are made available in Geographic Information System (GIS) format through http://www.gis.ssd.nesdis.noaa.gov/. A variety of geophysical products derived from both NOAA

and non-NOAA polar orbiting platforms can be found at http://www.osdpd.noaa.gov/PSB/PSB.html.

NESDIS continues to support the Cospas-Sarsat Program through provision of satellites, ground stations, and alert data distribution services. In 2004, Cospas-Sarsat contributed to the rescue of 1,465 people worldwide and 260 people in the U.S. The Cospas-Sarsat program consists of Russia, the U.S., India, France, and Canada providing the space segment and 31 other countries providing ground systems to relay distress alerts and participate in the management of the program. NESDIS operates and maintains the U.S. SARSAT Mission Control Center and twelve Local User Terminals as ground stations.

The Local User Terminals receive 121.5/243/406 MHz emergency beacon signals directly from the satellites and process the information to provide the location of distress transmissions. Cospas-Sarsat will terminate satellite processing of 121.5/243 MHz signals beginning February 1, 2009. This decision was made in response to guidance from the International Civil Aviation Organization and the International Maritime Organization. These two specialized agencies of the United Nations are respectively responsible for international aviation and maritime search and rescue standards. The use of new emergency beacons that can use the Global Positioning System (GPS) to provide an accurate position continues to increase. NESDIS, working with its partners in the U.S. Air Force, U.S. Coast Guard and NASA, is developing plans to augment the Cospas-Sarsat System with search and rescue instruments on future Global Positioning System (GPS) Block III satellites.

NATIONAL ICE CENTER.

The U.S. National Ice Center (NIC), under sponsorship of the U.S. Navy, NOAA, and the U.S. Coast Guard (USCG), is tasked with providing the highest quality operational global, regional, and tactical scale sea ice analyses and forecasts, tailored to meet the requirements of U.S. national interests. NIC ice products are produced in a digital workstation environment using data from polar orbiting satellites, ship/shore station reports, drifting buoys, meteorological guidance products, ice model predictions, and government partners including foreign ice services. The primary remotely sensed data sources used for global and regional-scale ice mapping are visible and infrared imagery from the POES Advanced Very High Resolution Radiometer (1.1 km spatial resolution) and the DMSP Operational Linescan System (0.55 km spatial resolution). In areas of extensive cloud cover, the NIC uses Special Sensor Microwave Imager (SSM/I) sensor data (19 and 37 GHz channels) processed using the CAL/VAL and NASA Team ice concentration algorithms. These algorithms produce 25 km griddled mosaic ice maps that are instrumental in the production of NIC weekly composite Arctic/Antarctic ice maps. Higher resolution ice analysis products, used to ensure the safety of navigation and protect life and property at sea, are dependent upon availability and use of Synthetic Aperture Radar (SAR) data from the Canadian RADARSAT-1. RADARSAT's ScanSAR wide mode produces a 500 km wide swath with 100 m spatial resolution. Images are processed at four different ground stations and transferred to the NIC via dedicated communication lines or via the Internet within six hours of acquisition. The NIC science team, which assists in the transition of pertinent scientific research to operations, is working on the transition of real-time passive and active microwave sea ice products to the NIC operations floor, conducting an evaluation of current sea ice algorithms, and the use of satellite and in-situ data for initializing and evaluating the Polar Ice Prediction System (PIPS).

Routine NIC ice guidance products include regional-scale ice maps, annotated satellite imagery, short and long-term ice forecasts, and legacy ice information and ice climatology. Specialized support services include specific regional support, ship route recommendations, pre-sail ship briefings, aerial ice reconnaissance, and ship rider support. Specific sea ice features analyzed include ice edge position, ice concentration, ice thickness, form or floe size, ice motion, areas of compression and heavy surface deformation, and the location/orientation of open water or thin ice-covered leads. Ice products are disseminated via the Internet (www.natice.noaa.gov) as simple electronic charts in Joint Photographic Experts Group (JPEG format), GeoTiff and other GIS-compatible coverages in the World Meteorological Organization (WMO) digital standard for Sea Ice in GRIDDED (SIGRID-3) format. Date and time of data acquisition as well as the per-

centage of each data type used in all ice analyses are documented in a metadata narrative.

Another NIC responsibility is oversight of the U.S. Interagency Arctic Buoy Program (USIABP). The USIABP was established in 1992, to provide the management structure and coordination necessary to maintain a baseline network of drifting buoys. Buoys within the array provide sufficient spatial resolution to define surface ,synoptic scale atmospheric pressure, air temperature, and sea-ice drift fields. Data are used in real-time for operational weather and ice forecasting and for research in the Global Climate Change Program. The USIABP is a collaborative program that draws operating funds and services from the collective contributions of government agencies and/or programs. These organizations include: the Naval Oceanographic Office, Office of Naval Research (ONR), NASA, National Science Foundation (NSF), and NOAA's NESDIS, OAR, and the Office of Global Programs (OGP).

OFFICE OF RESEARCH AND APPLICATIONS.

The Office of Research and Applications (ORA) provides guidance and direction for NESDIS research and applications activities. It coordinates the efforts of the Climate Research and Applications Division, Atmospheric Research and Applications Division, and Oceanic Research and Applications Division. These divisions conduct studies on the use of satellite data to monitor environmental characteristics and change and develop algorithms to produce satellite products for applications to operational weather and ocean analyses and prediction. Further, ORA participates in the development of new spacecraft and sensors for future systems. It also carries out a vigorous program to calibrate and validate satellite data to ensure its quality for near-real-time and long-term studies. Additionally, ORA through division participation, actively educates others on technology transfer programs through scientific presentations, technical reports, Internet-based tutorials, and training workshops at domestic and international sites.

THE JOINT CENTER FOR SATELLITE DATA ASSIMILATION (JCSDA).

The JCSDA was created by a Memorandum of Agreement between NOAA and NASA, with affiliated partnerships with the U.S. Navy and U.S. Air Force. This cooperative agreement will allow NOAA, NASA, and DOD to work together to take advantage of their combined science and technology resources in order to accelerate the use of existing and new satellite data. The JCSDA will provide a focal point for joint research and development of common models and infrastructure among its partners. As a result of its collaborative nature, the JCSDA will allow NOAA to improve numerical weather and climate prediction through the optimal use of data from existing satellites and to prepare for the incoming flood of new data from advanced satellite instruments, such as NPOESS, that will be launched during the next five to six years. The JCSDA is tasked with developing new and powerful techniques to assimilate data into numerical weather prediction (NWP) and numerical climate prediction models. JCSDA activities directly support the missions of NASA, NOAA, and as DOD as well as those of other organizations who share or rely on NOAA's environmental assessment, prediction, and stewardship mission. In addition, through its partnership and coordination with DOD and other agencies, the JCSDA will enhance the Nation's ability to respond to increase data reporting and data sharing needs brought on by the renewed emphasis on homeland defense and national security concerns.

The initial projects within the JCSDA will focus on fully exploiting uses of current satellite data. As a part of efforts to facilitate the transition from research into operations, early projects will focus on maturing the process of transitioning these data into operations and developing tools to support future assimilation projects. Six initial scientific priorities have been identified:

• Develop a community-based radiative transfer model (CRTM) to be used by the JCSDA partners in their data assimilation systems. In the next few years, the accuracy and capability of the JCSDA CRTM will be significantly improved by including additional physical processes (e.g., atmospheric scattering) and better numerical techniques and better surface emissivity models to allow more satellite data which is affected by surface to be properly assimilated.

• Develop the data thinning and configuration technology and methodology that will allow faster and efficient delivery of advanced satellite data to major NWP centers in the U.S. and other international partners.

• Advance the techniques to assimilate satellite data in cloudy and precipitation regions by improving radiative transfer models and NWP cloud prediction scheme, thereby significantly increasing the fraction of satellite data being ingested into the assimilation systems.

• Improve the use of satellite land products (e.g., green vegetation fraction, snow cover, snow pack parameters, surface albedo, land, and sea sur-

face temperature) in NWP models.

• Improve the use of satellite data in ocean data assimilation by providing assimilated ocean data sets to the community for research purposes and providing access to and support of an operational ocean data assimilation system.

• Assimilate satellite derived aerosol, ozone and trace gas products to improve forecasts of visibility and health index with the state-of-the-art air quality forecast model including chemical and biological process.

In addition, the JCSDA has a long-term strategic goal of improving the transfer of data assimilation research into operations by fostering common data assimilation code components, including techniques for specifying observation errors, background error co-variances, and data selection and reduction.

The JCSDA approach is already generating measurable accomplishments. Recent accomplishments include:

1. Improved radiative transfer techniques:

• Microwave land emissivity model implemented in NCEP operational global data assimilation system (GDAS).

• Community fast radiative transfer model implemented operationally in the GDAS.

• More AMSU-A data are used over land, snow and sea ice conditions

2. Improved uses of current satellite data:

• More AMSU-A data are used over land.

• Increased use of HIRS, AMSU-A data in stratosphere.

• SSM/I, TRMM precipitation products.

• AMSU cloud liquid water.

• GOES-10 IR radiances.

• QuikSCAT winds.

3. More satellite data being used in NCEP operational models:

• SSM/I, TRMM precipitation products.

• AMSU cloud liquid water.

• GOES-10 IR radiances.

• QuikSCAT winds.

• MODIS winds.

POLAR SATELLITE PROGRAM.

The primary mission of the Polar-orbiting Operational Environmental Satellite (POES) System is to provide daily global observations of weather patterns and environmental measurements of the Earth's atmosphere, its surface and cloud cover, and the proton and electron flux at satellite altitude. Since the beginning of the POES program, environmental data and products acquired by its satellites have been provided to users around the globe. These satellites increase the accuracy of weather forecasting by providing quantitative data required for improved numerical weather forecast models. Currently, the two primary operational spacecraft are NOAA-17 and NOAA-18.

NOAA polar satellites carry instruments to provide atmospheric temperature and moisture profiles. In addition to taking thermal images of the earth's surface and atmosphere, the NOAA polar-orbiting satellites carry sounder instruments to provide vertical profiles of atmospheric temperature and moisture. They also provide multi-channel images and carry a data collection and platform location system, and a Search and Rescue Satellite-Aided Tracking (SARSAT) subsystem. The SARSAT subsystem is used to detect and locate distress alerts from maritime, aviation, and land-based users of emergency beacons operating at 121.5 or 243 or 406 MHz.

POES satellites carry four primary instrument systems: the Advanced Very High Resolution Radiometer (AVHRR); and the TIROS Operational Vertical Sounder (TOVS); the Space Environment Monitor (SEM); and the Solar Backscatter Ultra-Violet Instrument (SBUV/2). The AVHRR provides data for real-time transmission to both Automatic Picture Transmission (APT) and High Resolution Picture Transmission (HRPT) users and for storage on the spacecraft tape recorders for later playback. The AVHRR/3 series of instruments, which began with NOAA-15, measures in six spectral channels (0.63, 0.86, 1.6, 3.75, 10.8 and 12 μm) with a nominal spatial resolution of 1.1 km and global resolution of roughly 4 km. Though the AVHRR/3 measures 6 channels, only 5 are transmitted in the data stream at any one time; the 1.6 and 3.75 m channels are time shared. The AVHRR/3 provides stored and direct-readout radiometer data for day and night cloud cover, sea surface temperatures, vegetation indices, fire detection, and snow and ice mapping. TOVS is comprised of the High-resolution Infrared Radiometer Sounder (HIRS) and the Advanced Microwave Sounding Unit (AMSU).

The HIRS/3 is a discrete-stepping, line scan instrument designed to measure scene radiance in 20 spectral bands to permit the calculation of the vertical temperature profile from Earth's surface to about 40 km. Multi-spectral data from one visible channel (0.69μm), seven shortwave channels (3.7 to 4.6μm), and twelve long wave channels (6.5 to 15μm) are obtained from a single telescope and rotating filter wheel containing twenty individual filters. An elliptical scan mirror provides cross-track scanning of 56 increments of 1.8μm. The mirror steps rapidly (<35 msec), then holds at each position while the 20 filter segments are sampled. This action takes place each 100 msec. The instantaneous field of vision (FOV) for each channel is approximately 1.4μm in the visible and shortwave IR, and 1.3μm in the long wave IR band that, from an altitude of 833 km, encompasses an area of 20.3 km and 18.9 km in diameter, respectively, at nadir on the Earth.

Each AMSU-A instrument is composed of two separate units:

(a) AMSU-A2 with two channels at 23.8 and 31.4GHz and (b) AMSU-A1 with twelve channels in the range of 50.3 to 57.3GHz and one channel at 89.0GHz. The AMSU-B has five channels with frequencies centered on 89, 150, 183±1, 183±3, and 183±7Ghz, respectively. AMSU-B, provided by the United Kingdom Meteorological Office, produces soundings of humidity from the surface to 200 millibars (mb). AMSU-A has a nominal FOV of 3.3 degrees (48 km on surface at nadir) and AMSU-B a field of view of 1.1 degrees (16 km on surface at nadir). AMSU-A (AMSU-B) samples 30 degrees (90 degrees) Earth views, covering ±48.95 degrees from the subsatellite point. In addition, the specialized 89GHz channel, with the capability to "see" through high and mid-level clouds to low level precipitation producing clouds, is used to determine the position and structure of tropical cyclones on a global scale. The AMSU-A1 uses two antenna systems, providing observations in the twelve oxygen band channels (3-14) for retrieving the atmospheric temperature profile from the Earth's surface to about 42 km, or from 1000 to 2 mb. The remaining three channels (1 and 2 from A2 and 15 from A1) aid the retrieval of temperature soundings by correction of surface emissivity, atmospheric liquid water, and total precipitable water. These window channels also provide information on precipitation, sea ice, and snow coverage.

The SEM measures solar proton flux, alpha particle and electron flux density, and energy spectrum and total particulate energy distribution at spacecraft altitudes. The two sensors included within this instrument are the Total Energy Detector (TED) and the Medium Energy Proton and Electron Detector (MEPED), in addition to a common data processing unit. This instrument augments the measurements made by NOAA's geostationary satellites.

The NOAA-16, NOAA-17, and NOAA-18 POES carry the SBUV/2. The SBUV/2 instrument is a non-scanning (fixed nadir viewing) spectrometer designed to measure scene radiance and solar spectral irradiance from 160 nanometers to 400 nanometers. Data obtained from the instrument are used to compute the amount and vertical distribution of ozone in the Earth's atmosphere on the sunlit side of the Earth. Ozone evaluation, calibration, and validation activities took place for the new Solar Backscatter Ultraviolet Instrument (SBUV/2) with the launch and successful checkout of NOAA-17 & 18. A new ozone profile retrieval algorithm (Version 8) is under development at NASA. As soon as it becomes available, NOAA will begin to incorporate it in its SBUV/2 processing systems.

Monitoring of global ozone will continue with the SBUV/2 instruments on NOAA-14, NOAA-16, NOAA-17, NOAA-18, and with the TOVS instruments on NOAA-14, NOAA-15, NOAA-16, NOAA-17, and NOAA-18. Experimental ozone products at high temporal resolution are also being produced from the GOES-8 sounder channels. Monitoring is limited to North America. Preliminary results show the GOES total ozone values are comparable to amounts from the Total Ozone Mapping Spectrometer and ground-based measurements.

The ground system required to receive large volumes of digital data from NOAA satellites consists of two major subsystems: the Polar Acquisition and Control Subsystem (PACS) and the Central Environmental Satellite Computer System (CEMSCS). The PACS includes the Wallops, Virginia, and Fairbanks, Alaska, Command and Data Acquisition (CDA) stations and the SOCC at Suitland, Maryland. All the CEMSCS components are in the NOAA facility at Suitland. PACS is used to command and control the spacecraft, monitor its health via housekeeping telemetry, and retrieve and transmit the spacecraft environmental data to the CEMSCS processing and data handling facility. The delivery of NOAA system data from the CDA to Suitland is accomplished by using the General Electric American Communications, Inc. commercial satellite communications network. This system, which includes Earth stations at Suitland, Wallops, and Fairbanks, delivers the data to SOCC. These data are immediately passed to the CEMSCS for processing. The CEMSCS ingests the raw satellite data and pre-processes and stores them along with appended auxiliary information, such as Earth location, calibration, and quality control parameters. The data processed by the CEMSCS are used for environmental products and operational weather predictions that are disseminated to users throughout the world.

The Argos Data Collection (and location) Service (DCS) operates on the NOAA Polar-orbiting Operational Environmental Satellite (POES) constellation and was established through a Memorandum of Understanding (MOU) with France in 1974. NOAA for the U.S. and the Centre Nationale d'Etudes Spatiales (CNES) for France are the lead agencies for this international cooperative agreement. CNES provides for the development and delivery of the Argos DCS instrument. NOAA provides spacecraft integration/launch services, downloads stored mission data via NOAA Command Data Acquisition facilities and provides pre-processed data delivery. Data post-processing and delivery to customers is the responsibility of CNES, which through a subsidiary maintains distribution centers located in Toulouse, France and Largo, Maryland.

The Argos DCS is a space-based, data telemetry system that provides a global means to locate and collect environmental data from fixed and

moving, low-power transmitters; i.e., polar ice flows, ocean buoys, birds, mammals, etc in near-real time (15 minutes - 3 hours). The Argos DCS transmits data for operational and research related environmental applications, e.g. meteorology, oceanography and protection of the environment, with the majority of users being government/non-profit agencies and researchers. Argos DCS customers are engaged in over 1000 programs operating approximately 15,000 data collection platforms in 72 counties.

The Argos DCS program continues to develop international partnerships and will incorporate Argos instruments on other international satellite platforms, such as the European Organization for Exploration of Meteorological Satellites (EUMETSAT) METOP satellite series (2005-2010). An instrument upgrade, called the Argos Advanced Data Collection System (A-DCS), incorporates a downlink message capability is scheduled to fly on the NOAA-N' satellite and the National Polar-orbiting Operational Environmental Satellite System (NPOESS) constellation (2009-2018). This new capability, is in response to customer requirements, and will provide the opportunity for new and novel uses of the Argos DCS

GEOSTATIONARY SATELLITE PROGRAM.

Two operational geostationary satellites, GOES-12 (75 degrees W) and GOES-10 (135 degrees W), provide coverage of virtually the entire western hemisphere for operational environmental sensing of the Earth. Additionally, GOES-9 is now located over the western Pacific. The GOES-9 imager replaced the GMS-5 of the Japanese Meteorological Agency as of April 1, 2003, which will be replaced by the Japanese MTSAT-1R in 2005.. The sounder is operating in an experimental mode. The projected launch schedule and associated instruments for geostationary satellites are shown in Table 3.1. It should be noted that current plans as of mid 2005 call for GOES-N to be placed in storage once launched in CY 2005, with GOES-11 (currently in storage) to replace GOES-10 in the west and GOES-12 to remain in the east.

The GOES satellites host an imager capable of detecting atmospheric, sea surface, and land properties in five spectral bands including the 3.9µm and 12.0µm wavelengths. However, beginning with GOES-12, the 12.0µm channel is replaced with a 13.3µm channel, with the goal of achieving more accurate cloud height assignments for mid- and upper-level atmospheric satellite wind-velocity estimates. Unfortunately, this trade-off notably impacts the sea-surface temperature retrievals by eliminating the capability for daytime split-window retrievals, increasing the rms error by about 0.5 degrees C. Also, the spatial resolution of the water vapor channel is improved to 4 km from 8 km.

GOES satellites transmit all five spectral bands simultaneously, providing the user community with continuous views of atmospheric measurements in various wavelengths, each with its own atmospheric, land, and ocean application. GOES spacecraft were designed for flexible scanning of the Earth; a variety of scans or sector coverage can be scheduled.

For example, the full-earth disk is normally scanned once every 3 hours and requires about 30 minutes to complete the entire scan. Depending on requirements to monitor environmental hazards on the Earth's surface or in the atmosphere, 30-minute periods in between the full-disk scans may be scheduled as a mixture of 15-minute intervals (routine operations) or 7½-minute interval (severe storm operations) rapid scans over the contiguous U.S. To further support mesoscale and microscale analyses, 1000 km by 1000 km areas can also be scanned at 1-minute intervals, to capture rapidly developing and dynamic environmental phenomena..

The five channels and respective resolutions are as follows:

- Channel 1 (Visible, .55 m to .75 m) 1 km
- Channel 2 (Infrared, 3.8 m to 4.0 m) 4 km
- Channel 3 (Water Vapor, 6.5 m to 7.0 m) 8 km (4 km starting with GOES M)
- Channel 4 (Infrared, 10.2 m to 11.2 m) 4 km
- Channel 5 (Infrared, 11.5 m to 12.5 m) 4 km

The GOES sounder instruments, consisting of 19 spectral channels, are used for measurements of atmospheric temperature and moisture profiles, surface and cloud top temperatures, and ozone distribution. Products derived from the sounder include precipitable water and a lifted index (a measurement of atmospheric stability). Comparable to the imager, the sounder is capable of providing various scan coverages, such as full Earth imagery, sectored imagery, and local imagery. In routine operations, GOES-12 and GOES 10 provide hourly sounding coverage.

The GOES Space Environment Monitor (SEM) collects data for warnings of solar activity. This block of instruments is more extensive than on POES. The GOES SEM instruments include X-ray monitors that detect solar flares, energetic particle sensors, and three component vector magnetometers to measure changes in the ambient magnetic field. Real-time SEM data are used to support operational NOAA and DOD space environment forecasts and alerts. Data from GOES SEM sensors are archived by the National Geophysical Data Center and provided to retrospective users on line via Internet and on a variety of computer media. GOES-12 has the Solar X-Ray Instrument that provides near-real time x-ray images of the sun.

TABLE 3.1 PROJECTED SATELLITE LAUNCH SCHEDULE

POLAR-ORBITING SYSTEM

Satellite Designator	Planned Launch Date*
NOAA-N	CY 2005
METOP-2	CY 2010
NPP	CY2008
NOAA-N'	CY 2007
NPOESS-C1	CY 2009
METOP-1	CY 2006
NPOESS-C2	CY 2011
NPOESS-C3	CY 2013
METOP-3	CY 2015
NPOESS-C4	CY 2016**
NPOESS-C5	CY 2018**
NPOESS-C6	CY 2019**

GEOSTATIONARY SYSTEM

Satellite Designator	Planned Launch Date*
GOES N	CY 2005
GOES O	CY 2007
GOES P	CY 2008
GOES Q	Cancelled
GOES R	CY 2012
GOES S	CY 2014
MTSAT-1R	CY 2005

*Launch date depends on performance of prior spacecraft and is subject to change.
** Dates are approximate. NPOESS is a launch on demand system.

NOAA Instruments for NOAA Polar-Orbiter and METOP Series

AVHRR - Advanced Very High Resolution Radiometer
SEM - Space Environment Monitor
SBUV - Solar Backscatter Ultraviolet Instrument (NOAA PM mission only)
HIRS - High Resolution Infrared Sounder
DCS ARGOS - Data Collection System
AMSU-A - Advanced Microwave Sounding Unit-A
AMSU-B - Advanced Microwave Sounding Unit-B
SARP - Search and Rescue Processor
SARR - Search and Rescue Repeater
MHS - Microwave Humidity Sounder (NOAA-N/N' and METOP)

Instruments for NPOESS Series

VIIRS - Visible/Infrared Imager/Radiometer Suite
CMIS - Conical Microwave Imager/Sounder
CrIS - Cross-track Infrared Sounder
ATMS - Advanced Technology Microwave Sounder
OMPS - Ozone Mapper/Profiler Suite
SES - Space Environment Suite
A/DCS - Advanced Data Collection System
SARSAT - Search and Rescue Satellite-Aided Tracking System
ERBS - Earth Radiation Budget Sensor
TSIS - Total Solar Irradiance Sensor
ALT - Altimeter (Dual Frequency radar altimeter)

Instruments for GOES-R+ Series

Advanced baseline Imager (ABI)
Hyperspectral Environmental Suite (HES)
Solar Instrument Suite (SEI)
Space Environment In-Situ Suite (SEISS)
Geostationary Lightning Mapper (GLM)

EUMETSAT Unique Instruments for METOP Series Satellites

ASCAT - Advanced Scatterometer
GOME - Global Ozone Monitoring Experiment
GRAS - GPS Receiver for Atmospheric Sounding
IASI - Infrared Atmospheric Sounding Interferometer

GOES also carries a Data Collection System (DCS), which is used to collect and relay environmental data observed by a variety of remotely located platforms, such as river and tide gauges, seismometers, buoys, ships, and automatic weather stations. In support of NOAA missions, GOES DCS data are used in weather forecasts and warnings, reservoir control, and flood monitoring. While the GOES DCS is a critical element for national and international meteorological and hydrological programs, the NWS NEXRAD program relies on the DCS data as a vital input for calibration and validation. Tsunami watches and warnings for the Pacific Ocean are prepared using the Data Collection Platform data transmitted via GOES DCS. The GOES DCS program touches all aspects of our lives in supporting water quality, air pollution, and global environmental monitoring.

The GOES Search and Rescue Satellite Aided Tracking (SARSAT) System is capable of providing an immediate distress alert, unlike the POES satellite SARSAT transponders which must come within line of site of a Local User Terminal, in order to relay the distress beacon back to the U.S. SARSAT Mission Control Center (USMCC). Newer state of the art Cospas Sarsat distress beacons, utilizing the Global Positioning System (GPS), now have the capability to provide location information in the distress message relayed by GOES to the USMCC.

NESDIS continues to improve user access to its operational satellite products and services using new communications technologies, including the Internet. One important on line access system, managed and operated by OSD is the Comprehensive Large-Array Data Stewardship System (CLASS). The CLASS (www.CLASS.noaa.gov) provides satellite data access, display, and electronic transfer. Available data types include AVHRR, ATOVS, DMSP (special sensor), and RADARSAT (authorized subscription users). While developed as an independent system, the CLASS serves as NOAA's initial interoperable interface to NASA's Earth Observing System Data and Information System (EOSDIS). After the phase out of the GOES TAP system in 1998, many users now rely on GOES sectorized images, mapped to standard AWIPS grids, available in near real time at www.goes.noaa.gov.

Near real time images and interpretive analyses of tropical storms and hurricanes worldwide, ash from volcanic eruptions within the western hemisphere, heavy precipitation in the U.S. which cause flash flooding or blizzards, wild fires and smoke within the U.S., and northern hemisphere snow boundaries are located at www.ssd.noaa.gov. Specially enhanced and annotated imagery and image loops of environmental events, such as flooding, hurricanes and other severe storms, volcanic eruptions, fires, and dust storms are available from www.osei.noaa.gov. This web site was set up for use by the news media and general public, and to provide once or twice per day satellite views of an environmental event for Federal, state, and international governments and agencies. Also supporting the media, scientific organizations, and federal and state agencies is a specially designed web site featuring visualizations of satellite data, found at www.nnvl.noaa.gov/.

INTERNATIONAL AND INTERAGENCY SUPPORT FOR DISASTER MANAGEMENT

International Charter.

NOAA, on behalf of the U.S., is a signatory to the International Charter for Space and Major Disasters, and serves in the capacity of Emergency on-Call Officer (ECO) on a rotational basis with other representatives of international space agencies. NOAA is also represented on the Executive Secretariat of the International Charter and periodically serves as the lead agency providing secretariat services, policy leadership, and Charter activities coordination.

The International Charter aims at providing a unified system of space data acquisition and delivery to those affected by natural or man-made disasters through authorized users. Each member agency (six space agencies representing Europe, France, Canada, India, Argentina and the U.S.) has committed resources to support the provisions of the Charter and thus is helping to mitigate the effects of disasters on human life and property. An authorized user can call a single number to request the mobilization of the space and associated ground resources of the six space agencies to obtain data and information on a disaster occurrence.

World Summit on Sustainable Development (WSSD) Follow-up.

NOAA plays a key leadership role in the Committee on Earth Observation Satellites (CEOS) World Summit on Sustainable Development (WSSD) Follow-up Program's module addressing Disaster Management and Conflicts. To address the priorities outlined at the WSSD and the specific references to satellite applications, NOAA and other CEOS members are putting together a program plan to increase awareness in the applications and utilization of Earth observation data in developing countries for disaster management and conflicts, as well as to assist in the establishment of infrastructure and communications in support of disaster management and conflicts. The module on Disaster Management will be initiated this year.

U.S. Interagency Collaboration.

NOAA is a member (and chair) of the U.S. Subcommittee on Disaster Reduction (SDR), which provides a unique Federal forum for information sharing; development of collaborative

opportunities; formulation of science- and technology-based guidance for policy makers; and dialogue with the U.S. policy community to advance informed strategies for managing disaster risks. This year the SDR, through the U.S. President's National Science and Technology Council, released an interim report entitled *Reducing Disaster Vulnerability Through Science and Technology*, which identified critical opportunities to reduce future loss of life and property as a result of disasters. The report identifies several important themes relevant to disaster reduction and speaks to resources, opportunities, and gaps in science and technology needed to support disaster management.

IGOS Geohazards Theme.

As Co-Chair of the Integrated Global Observing Strategy (IGOS) in 2003, NOAA played a key role in facilitating the formal adoption and recent publication of the *IGOS Geohazards Report*. This report looks at global geohazards observation requirements and outlines an integrated implementation mechanism and action plan for filling the observation gaps over the coming decade. It also examines the impacts of geohazards on society, discusses the roles of implementation by stakeholders, addresses data management issues, and analyses the critical gaps in capacity building and infrastructure. More information is available at http://ioc.unesco. org/igospartners/Geohazards.htm.

CEOS Disaster Management Support Group (DMSG) Legacy.

NOAA led the DMSG effort within CEOS with an objective to support natural and technological disaster management on a worldwide basis by fostering improved utilization of existing and planned Earth observation satellite data. Particular emphasis was placed on working closely with space agencies, international and regional organizations, and commercial organizations on the implementation of these recommendations. Hazards addressed include drought, earthquake, fire, flooding, landslides, oil spill, sea ice, and volcanic hazards. The final report of the DMSG, published in 2002, can be accessed at http://www.ceos.org/pages/DMSG/index.html /.

SUPPORTING RESEARCH PROGRAMS

ATMOSPHERIC WINDS.

Recent advances in numerical weather prediction (NWP) models, both at NOAA's NCEP/EMC and other major International NWP Centers, require higher quality satellite-derived winds, particularly over the traditionally data void oceanic regions of the globe. The NESDIS GOES East and West wind processing suites are totally automated and use a series of geostationary satellite images to derive wind estimates. The automated winds algorithm uses an objective pattern matching technique to estimate velocity, and satellite water vapor and infrared brightness temperature data to assign heights to these derived wind estimates. The automated quality control of image registration is also an important component of the NESDIS GOES East and West winds processing suite.

Approximately 20,000 cloud-drift and water vapor motion wind vectors are derived from both satellites for each cycle and distributed to EMC and to the Global Telecommunications System (GTS). EMC uses these operational NESDIS wind products in their global and regional data assimilation/numerical forecast systems. NESDIS recently completed the effort to reformat the winds in WMO-sanctioned BUFR format. Current work involves the investigation of a slow bias seen in water vapor winds.

The newest satellite wind products include the low-level high-density visible satellite winds. During the daylight hours, visible channel data can be used to track cloud motions. The GOES visible imagery offers high horizontal resolution (1 km) and frequent image sampling (15-30 minutes nominally; higher in special rapid scan modes). The visible channel can depict lower tropospheric cumuliform tracers in areas not covered by opaque cirrus. In terms of tropical cyclones, visible winds can depict the low-level flow in the outer storm vortex region, which is an important area in assessing storm motion. The GOES satellites have an atmospheric sounder that includes two water vapor channels centered at 7.0µm and 7.3µm. These sounder channels can be employed as surrogate imagers to track water vapor features radiating from the lower layers of the troposphere. The weighting function of the 7.0µm channel peaks around 450mb and the weighting function of the 7.3µm channel peaks around 550mb. Water vapor winds generated from these two channels will compliment the imager-based cloud-drift and water vapor winds, resulting in an improved three-dimensional depiction of the wind field. The implementation of these new algorithms and the visible wind products into the operational environment at NESDIS began in 1999. These wind products can be viewed at orbit-net.nesdis.noaa.gov/goes and cimss.ssec.wisc.edu/tropic/real-time. Digital sounding and winds files are available through a GOES computer server within OSDPD.

ATMOSPHERIC MOISTURE AND STABILITY PRODUCTS.

Research continues to improve the atmospheric moisture and stability products from the GOES-12 and GOES-10 sounder instruments. Precipitable water for three layers of the atmosphere: surface to 900 hPa; 900-700 hPa; and 700-300 hPa are computed from the soundings. Total precipitable water (TPW) for the entire atmospheric column, from the earth's surface to the "top" of the atmosphere,

is also computed. These precipitable water products are particularly valuable for the short-term forecasting of precipitation, locating those environments favorable for heavy precipitation and flash floods, thunderstorms, and fog. Hourly updates of this information provide useful information for the EMC regional data assimilation systems and for weather forecasters in the field. EMC currently uses the GOES precipitable water retrievals as input to Eta Data Assimilation System (EDAS), which provides the initialization for the Eta forecast model. NESDIS is currently aiding EMC with running global and regional model impact analyses to improve and optimize the use of the GOES derived products in numerical weather prediction schemes. As of July 8, 2003, the hourly cloud-top information from the GOES sounder data are being assimilated into the operational National Centers for Environmental Prediction (NCEP) Eta Data Assimilation System (EDAS). The regional Eta model joins the Rapid Update Cycle (RUC) model as two operational models assimilating GOES sounder cloud information to help improve the initial moisture and cloud field. At present, a blended GOES, SSM/I, and model-derived product is being evaluated. In addition, a precipitable water product has been developed from the POES AMSU sensor and is presently operational. In the near future, the blended product will include the AMSU-derived precipitable water. In addition to the moisture products, numerous atmospheric stability indices can be computed from measurements made by the GOES sounder instrument. Two stability indices, the lifted index (LI) and CAPE index, are computed on a routine basis. Since these indices are produced hourly, sequential images of these derived quantities clearly show the diurnal and dynamic changes associated with weather events.

So, in addition to providing these data to EMC for use in numerical weather prediction models, the graphical representation of these products allows for the looping of the products in time. This capability aids NWS forecasters in the field, for example, to understand the time evolution of severe storms. Because channel noise has improved with each successive sounder instrument it is anticipated that the GOES sounder moisture and stability products with a horizontal resolution of approximately 50 km, will be generated at a high horizontal resolution of approximately 10 km in the fall of 2003 (Figure 3-DOC-6).

The increased horizontal resolution offers exciting possibilities for enhanced use of these products in mesoscale forecasting. For example, it improves the depiction of gradients in the retrieved products, such as moisture and atmospheric stability, which focuses attention to a local area of interest. These products can be viewed at orbit-net.nesdis.noaa. gov/goes and cimss.ssec.wisc.edu. Digital versions of these products are available from POES and GOES computer servers within OSDPD.

TROPICAL CYCLONE MONITORING.

NESDIS continues to improve upon satellite-based techniques for estimating tropical cyclone positions and intensities, and for describing the internal structure of these storms. Recent sensors, such as AMSU and TRMM, among others, are being incorporated into the NESDIS operational tropical

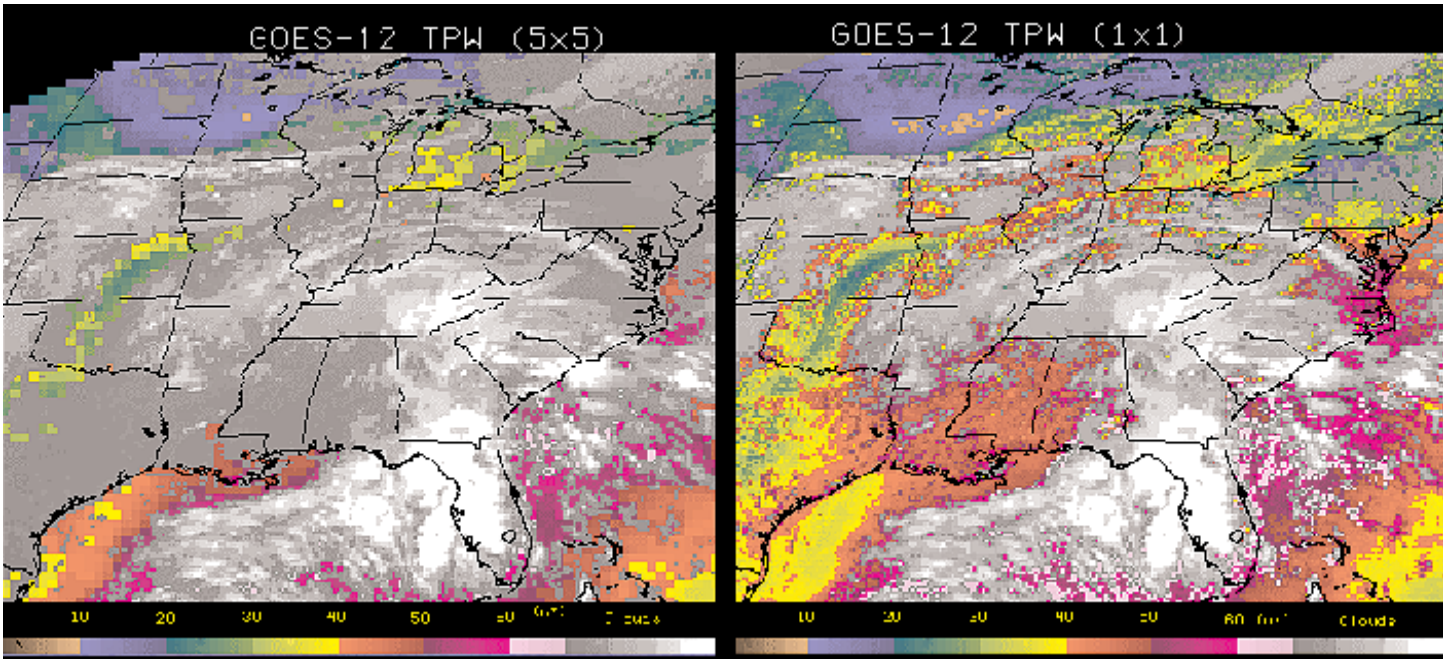


Figure 3-DOC-6. GOES-12 retrieved total preciptable water products at 50 km resolution (left) and 10 km resolution (right)

program, which supports the NWS and DOD hurricane programs. Real-time imagery and NESDIS tropical text messages can be viewed at www.ssd.noaa. gov/SSD/ML/real-time.html. Research is also being performed to improve the forecasts of tropical cyclone formation and intensity change by making better use of satellite observations.

PRECIPITATION ESTIMATES.

The Hydro-Estimator (H-E)--a fully automated adaptation of the semi-manual Interactive Flash Flood Analyzer (IFFA)--produces estimates of instantaneous precipitation rate based on GOES infrared data every 15 minutes. The H-E adjusts its computed rain rates for moisture availability, subcloud evaporation, orographic uplift, and other factors using Eta model fields. The resulting estimates are also the basis for 0-3 hour nowcasts of precipitation via an algorithm for extrapolating cell movement and development called the Hydro-Nowcaster. Other techniques being tested include the GOES Multi-Spectral Rainfall Algorithm (GMSRA), which uses four of the five GOES Imager channels for more precise rain area identification, and a combined GOES and microwave rainfall algorithm (developed at NRL/Monterey) which uses microwave-based rainfall estimates to modify its calibration. Real-time graphics from all three of the above techniques can be accessed at http://orbit-net.nesdis.noaa.gov/arad/ht/ff/index.htm, and real-time validation statistics for these algorithms are available at http://orbit-net.nesdis.noaa.gov /arad/ht/ff/validation/validation.html.

The H-E is now also available to NWS field forecasters via AWIPS. In addition, an improved AMSU-B rain rate algorithm is being implemented, and a new precipitation algorithm has been developed using the AMSR-E is under development. The AMSU-B products are available at http://orbit-net.nesdis.noaa.gov/arad2/MSPPS/index.html, including global long-term estimates for climate monitoring and analysis. Finally, the POES-based microwave algorithms from the microwave sensors are being used to produce automated 24-hour Tropical Rainfall Potential (TRaP) forecasts worldwide (Figure 3-DOC-7). Real-time TraP graphics can be accessed at http://www.ssd.noaa.gov/PS/TROP/trap-img.html.

MICROBURST PRODUCTS.

Several experimental microburst and convective wind gust products are being tested. These products, including the Wind Index (WINDEX) to compute maximum possible convective wind gusts and the Theta-e Deficit (TeD) and Dry Microburst Index (DMI) to compute the potential for wet and dry microbursts, respectively, use sounder data from both GOES-East/West. They are produced hourly and can be viewed at http://www.orbit.nesdis.noaa.gov/smcd/opdb/aviation/mb.html

In addition, a new wet microburst index product, designated as the Wet Microburst Severity Index (WMSI) is being developed and will be implemented in the suite of GOES microburst products. The WMSI assesses the potential severity of wet microbursts by summarizing the physical processes of convective storm development and downburst generation. The WMSI algorithm incorporates such parameters as convective available potential energy (CAPE), to represent the process of updraft formation, and Theta-e Deficit (TeD), to represent down burst development.

LOW CLOUD AND AIRCRAFT ICING PRODUCTS.

Fog and low clouds are a major source of air traffic delays and aircraft accidents. A nighttime, two-channel IR product from GOES has been developed to show regions where low

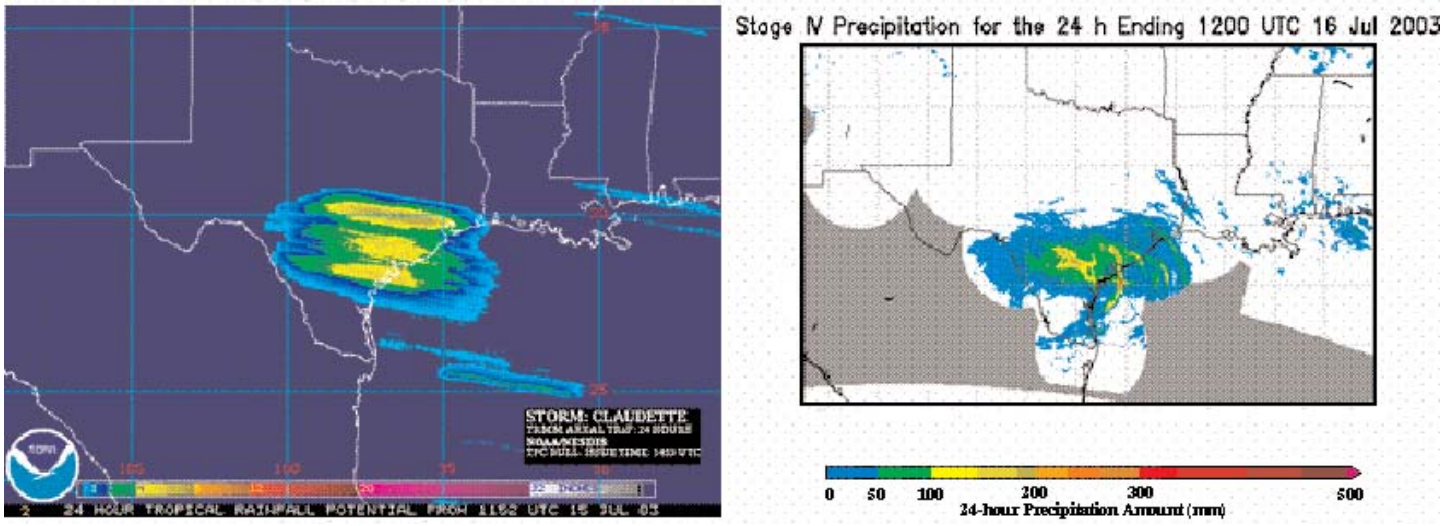


Figure 3-DOC-7. Tropical Rainfall Potential (TRaP) forecast for Hurricane Claudette (left) and corresponding Stage IV radar/rain gauge estimates (right) for the 24 hours ending 1200 UTC 16 July 2003.

ceilings (<1,000 ft) are likely to be found. This product is used to signal deteriorating weather conditions before they are reported by airport weather stations. Fog products for the Continental U.S. and Alaska are available on the Web hourly at: http://orbit-net.nesdis.noaa.gov/arad/fpdt/fog.html .

Areas of "super-cooled" water clouds that can result in hazardous aircraft icing are detectable from GOES by means of an experimental, multi-spectral product that uses a combination of several IR temperature and visible brightness thresholds. A recent innovation has combined this icing image with the GOES cloud-top height analysis to create an ICing Enhanced Cloud-top Altitude Product (ICECAP) **(**Figure 3-DOC-8)**.** The icing products are provided hourly day and night for the Continental U.S., Alaska, and the East Pacific at http://orbit-net.nesdis.noaa.gov/arad/fpdt/icg.html.

GEOSTATIONARY SEA SURFACE TEMPERATURES.

GOES-12 and GOES-10 are proving capable of producing sea surface temperatures (SST) over most of the Western Hemisphere nearly continuously. The accuracy and spatial resolution achieved with the GOES measurements are close to that achieved from the polar orbiting platforms, and GOES has a unique advantage of high temporal sampling frequency. Unfortunately, the trade-off of replacing the 12.0µm channel with a 13.3µm channel notably impacts the sea-surface temperature (SST) retrievals by eliminating the capability for daytime split-window retrievals, increasing the rms error by about 0.5 degrees C. For the SST determination, the frequent sampling by GOES makes a more complete map of SST possible after clouds have moved on. Additionally, a change in scene temperature over a short period of time may indicate the presence of clouds, thereby enhancing cloud detection.

The abundance of GOES observations helps to maintain a balance between high-quality, cloud-free observations and good geographical coverage of SST estimates. For the first time, GOES is enabling quantification of the diurnal variation of a radiometrically determined SST over large areas and long time periods. This quantification may have important implications in both numerical weather prediction and climate monitoring. NESDIS has been producing the GOES SST hourly product in an experimental configuration since December 1998, from both GOES East and GOES West. A global SST product is produced every three hours; regional SST products are generated every hour. These products were recently implemented operationally and can be accessed as digital files from the GOES computer servers within OSDPD.

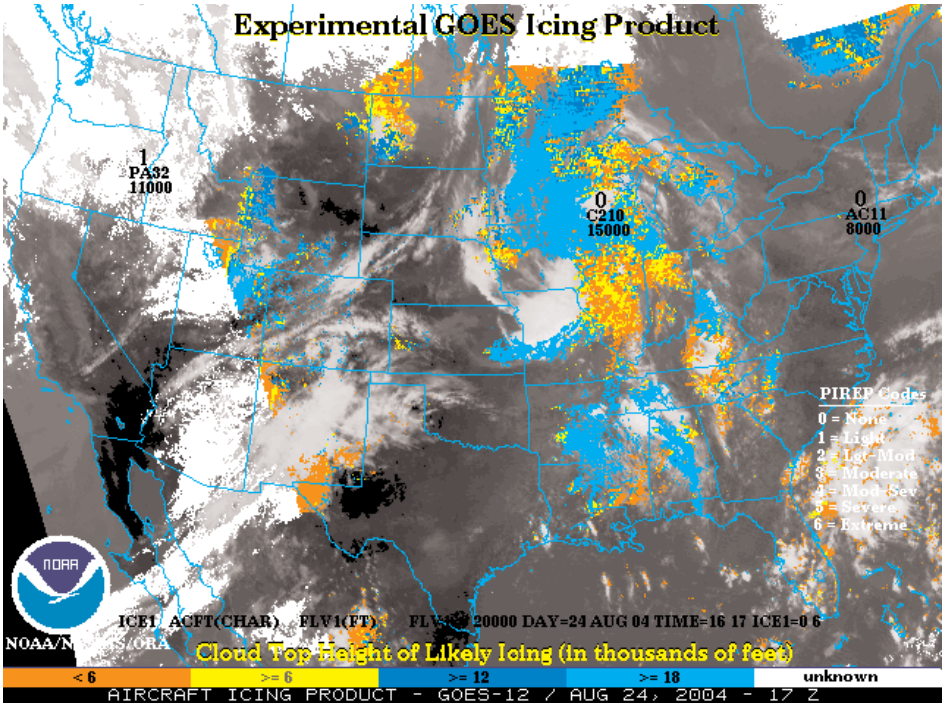


Figure 3-DOC-8. Areas of potential aircraft icing observed by GOES Imager are color-coded according to the estimated maximum cloud top height in 3,000 foot intervals, based on information from the GOES Sounder.

VOLCANIC ASH AND FIRE MONITORING.

A new technique has been developed to mitigate the loss of the 12 m IR band on GOES-12 to help track hazardous volcanic ash clouds. The technique uses IR channels centered at 10.7µm, 13.3µm, and 3.9µm. Several recent eruptions of Soufriere Hills volcano on Montserrat in the eastern Caribbean have shown that this new product is helpful in monitoring ash cloud emissions, even at night. GOES-12 ash product can be viewed for several volcanically active regions at http://www.ssd. noaa.gov /VAAC/ and http://orbit-net.nesdis.noaa.gov/arad/fpdt/volc.html. The analysis of Moderate Resolution Imaging Spectroradiometer (MODIS) data from the NASA Terra and Aqua spacecraft has also yielded valuable information about optimum detection of volcanic ash using several spectral bands. A three-channel combination product based on the 8.6, 11, and 12 m bands has been developed that provides effective discrimination of ash or sulfur dioxide gas with minimal false alarms. This algorithm could be applied to future products from NPOESS and GOES-R, which will

have similar spectral bands. Ash cloud advisory statements are provided by NESDIS to the aviation community over southern North America and northern South America, through the Volcanic Ash Advisory Center (VAAC) in Camp Spring, Maryland. GOES infrared and visible images, aerosol and sulfur dioxide products from NASA's Total Ozone Mapping Spectrometer (when applicable), and operational volcanic ash products for the Washington VAAC area of responsibility are found at http://www.ssd.noaa.gov/VAAC/washington.html.

Fire and smoke monitoring algorithms are being developed to automatically detect fires and to monitor their growth and the associated smoke coverage. GOES East spectral channels at 4µm and 11µm have been used to assess trends in South American burning practices over the past 6 years (1995-2000); GOES detected the most fire pixels in the tropical rain forest ecosystem in 1995. The application to clear sky human-initiated burning in South and Central America is now being adapted to monitor cloudy sky lightning and clear sky human-initiated fires in the Canadian provinces and the continental U.S. The continual monitoring from GOES (as often as every 7½ minutes) can assist firefighters to plan evacuation and suppression activities. Studies with Brazil are underway to predict smoke transport and air pollution and health alerts for major cities. An AVHRR fire detection algorithm has been developed for use in monitoring fire and smoke outbreaks around the world. All these new techniques will be used to improve the current operational fire and smoke product (Figure 3-DOC-9) used by the NWS Storm Prediction Center (SPC) in their fire outlook product and other users of fire and smoke detection such as the EPA, Forest Service, state and local agencies. Real time imagery of GOES and POES imagery in support of SPC can be found at: http://www.ssd.noaa.gov/PS/FIRE/.

A GOES Products and Services Catalog is available on line at http://orbitnet.nesdis.noaa.gov/arad/fpdt/goescat_v4/. An up-to-date list and description of operational and experimental products with links to the real-time products are available from this web page. The Polar Products and Services Catalog is under development.

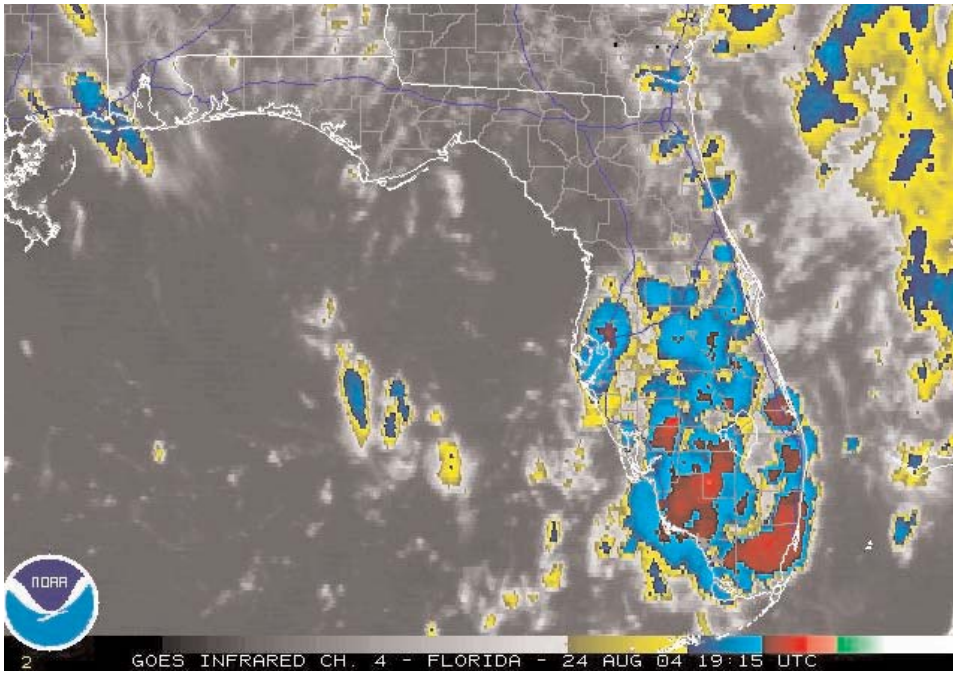


Figure 3-DOC-9. Probable fires appear as sharp white "spots" in the Reflectivity and Infrared images. These images are considered "raw" data, with no analysis of fires and/or smoke. To view official analyses by NOAA meteorologists, see the Hazard Mapping System Fire and Smoke Product.

NPOESS "TEST BED" DATA SETS.

ORA scientists continue to play an important role in the evaluation of proposed contractor sensor design and retrieval methods during the ongoing selection process for NPOESS. ORA scientists have created a variety of "test bed" data sets that are being used in the algorithm evaluation process. This is accomplished through participation in operational algorithm teams with the long-term goals of assuring capability to meet the requirements of all Environmental Data Records. Ozone evaluation, calibration, and validation activities took place for the new Solar Backscatter Ultraviolet Instrument (SBUV/2) with the launch and successful checkout of NOAA-17. A new ozone profile retrieval algorithm has been developed by NASA and is now incorporated into SBUV/2 processing systems. Monitoring of global ozone will continue with the SBUV/2 instruments on NOAA-14, NOAA-16 NOAA-17, and NOAA-18 and with the TOVS instruments on NOAA-14, NOAA-15, NOAA-16, NOAA-17 and NOAA-18. Experimental high temporal ozone products are also being produced from the GOES-12 sounder channels. Monitoring is limited to North America. Preliminary results show the GOES values are comparable to amounts from the Total Ozone Mapping Spectrometer and ground-based measurements.

LAND SURFACE PARAMETERS FOR USE IN WEATHER FORECAST MODELS.

Satellite-derived fields of land surface characteristics are being produced operationally for use in NWP models. These include radiation products deliv-

ered in near real-time as forcing variables; surface characteristics, such as fractional green vegetation and albedo, that specify model lower boundary conditions; and validation quantities, such as surface temperature. These products are meant to help the NWP models maintain better soil moisture fields which in turn results in better near surface temperature and humidity forecasts, and better precipitation forecasts. These fields now include POES-based (SSM/I and AMSU) estimates of surface emissivity, snow cover, sea-ice extent and concentration, land surface skin temperature, and soil wetness. Development of snow depth is underway. Plans are in the making to develop the AMSU-A Snow Water Equivalent (SWE) product for operational use. Forward models for surface emissivity at various microwave frequencies have been developed and are being tested in the forecast models. Algorithms to determine clear sky ice surface temperatures have been developed and delivered to Atmospheric Environment Service, Canada for evaluation. New techniques such as automatic edge detection and incorporation of new sensors such as AMSU and NASA's MODIS are in development to improve operational production of daily snow and ice extent products. These products are delivered as digital files to NWP models and to the NWS Climate Prediction Center and other users. Graphical imagery of operational northern hemispheric snow cover can be found on the Internet at www.ssd.noaa.gov/SSD/ML/ real-time.html #SNOW.

CLOUDS FROM AVHRR.

Algorithms are being developed, tested, and validated for determining cloud optical and microphysical properties from imager data such as the AVHRR. These algorithms are in addition to those already developed which estimate amounts and types for each observed cloud layer. The four cloud types are: L - Liquid Water Clouds; M - Mixed Phase Clouds; G - Glaciated Clouds (opaque); and H - High Ice Clouds (semi-transparent). Knowledge of cloud properties is important for both climate-scale and short-medium range forecasts. Accordingly, algorithms and processing systems to estimate cloud properties from imager data are being developed for both applications. Assimilation of cloud properties into NWP models is an objective of NCEP for improving short-medium range forecasts. Other applications of this work include the validation of simulated scenes to be used for the evaluation of new algorithm and instrument designs that is supported by the IPO. In addition, new algorithms are being developed to produce optimal estimates of cloud properties from both imager and sounder data, such as the merge of AVHRR and TOVS data.

AEROSOLS.

Aerosol retrievals from an improved and extended unique PATMOS-BUOY Data set were analyzed to optimize the procedure used in the aerosol correction of sea surface temperature (SST) retrievals. Based on the results, a new aerosol correction algorithm for SST has been developed and delivered to OSDPD for the use with NOAA-16-17 and -18 data. The new correction algorithm uses aerosol optical depth in AVHRR/3 channel 2 (0.83 m), only. The PATMOS-BUOY match up data set was also used for an extensive evaluation of the single-channel 3rd generation algorithm for aerosol retrieval from AVHRR. This aerosol algorithm has now been implemented in the operational aerosol observations (AEROBS) obtained from the AVHRR instrument onboard the NOAA 16 and 17 satellites.

The algorithm uses an improved treatment of atmospheric and surface effects, and provides aerosol optical depth data in three channels at 0.63, 0.83 and 1.6μm. The single-channel 3rd generation algorithm has also been implemented at NASA/LaRC in the Clouds and Earth's Energy System (CERES) SSF processing of aerosol optical depth from the MODIS instruments on the Terra and Aqua satellites. Aerosol data from this algorithm is produced in addition to the primary MODIS multi-channel retrievals. The single-channel retrievals serve as backup for the primary product. They also provide continuity with earlier NOAA/AVHRR aerosol retrievals, and facilitate the quantification of improvements offered by multi-channel retrievals over single-channel ones.

A comparison of the two aerosol products shows an overall good agreement on a global scale. This implies that the simple single-channel algorithm performs well relative to the more sophisticated and comprehensive MODIS multi-channel algorithm. The major differences between the two products appear to be related to the differences in cloud screening and identification of glint regions that lead to differences in sampling. The lessons learned from these and follow up comparisons will be applied to improve the current operational algorithm, and in the risk reduction of aerosol retrieval from VIIRS on the NPOESS satellites. The feasibility of aerosol optical depth retrieval from GOES over most of South and North America has also been demonstrated. A comparison of GOES-retrieved aerosol optical depth with that observed at the AERONET ground stations showed good agreement.

LONG-TERM MONITORING OF NOAA-15 ADVANCED MICROWAVE SOUNDING UNIT-A (AMSU-A) PERFORMANCE.

Since the launch of the NOAA-15 satellite, the AMSU-A level 1B data have been captured from the CEMSCS and stored on optical disks. These data are used for off-line characterization of

the instrument radiometric performance on orbit. Over 20 important radiometric parameters are extracted or calculated from the AMSU-A 1B data. NESDIS has already demonstrated that the noise in the observations in all channels is lower (better) than that required by the specifications and, in some channels, it is lower than estimates based on pre-launch test results. NOAA will continue compiling long-term trends of all the parameters to provide a better understanding of the instrument performance. The PC-based software developed for evaluating these data will be improved for better efficiency in processing the data.

CALIBRATION OF THE VISIBLE AND NEAR-INFRARED CHANNELS OF THE AVHRR.

The AVHRR flown on POES is recognized as an invaluable resource for satellite-based studies of the Earth system. The long-term records of geophysical products such as the Normalized Difference Vegetation Index (NDVI), columnar aerosols over the oceans, cloud morphology, and shortwave radiation budget play a central role in climate and global change studies by providing a means to study the environment continuously. It is thus very important to characterize and document the in-orbit performance of the AVHRR flown on the polar orbiters.

Toward this end, a very comprehensive program of post-launch calibration and characterization of the AVHRR has been implemented to ensure the accuracy, continuity, and viability of the various AVHRR-derived geophysical products, with particular attention paid to the visible (Channel 1: 0.58 - 0.68μm), and near-infrared (Channel 2: 0.72 - 1.1μm; Channel 3A: 1.58 - 1.64μm) channels which do not have any onboard calibration devices. The major program elements are: (a) development of an optimal vicarious post-launch calibration technique, utilizing radiometrically stable calibration sites, model simulations of the radiation measured by the sensors, and simultaneous radiation measurements by the AVHRR and by calibrated spectrometers onboard aircraft; (b) enhancement of available vicarious calibration techniques to improve attainable radiometric calibration accuracies beyond ±5 percent; (c) evaluation of the feasibility of using the International Space Station (ISS) as a platform to calibrate satellite sensors, in general, using radiometers on the ISS traceable to the National Institute of Standards and Technology (NIST); (d) establishment of the AVHRR as a traveling calibration standard to monitor the performance of sensors, such as the imager on the GOES, the visible channel of the High-resolution Infrared Radiation Sounder (HIRS), the Moderate-resolution Imaging Spectrometer (MODIS), and various sensors to be flown on ENVISAT; and (e) design of optimal onboard and vicarious calibration techniques for the visible and near-infrared sensors planned under the National Polar-orbiting Operational Environmental Satellite System (NPOESS). The relevance and importance of these activities has been recognized by the national and international user community, as evidenced by the appreciation and endorsement of the Working Group on Calibration and Validation (WGCV) and the Global Observing Systems Space Panel (GOSSP).

To ensure global access to the results of the AVHRR calibration program, and recognizing the importance of the AVHRR-derived products to national and international programs, such as the International Satellite Cloud Climatology Project (ISCCP), the International Geosphere Biosphere Programme (IGBP), the Global Climate, Ocean, and Terrestrial Observing Systems, and to benefit from sensor calibration research elsewhere, active liaison, and collaboration in some instances, has been established with researchers in NASA, NIST, EUMETSAT, China Meteorological Administration, Beijing, China; Rutherford Appleton Laboratory, United Kingdom; National Space Development Agency, Japan; the NOAA/NASA Pathfinder Program; several space agencies and remote sensing laboratories outside the U.S., and academia both in the U.S. and abroad.

CALIBRATION OF GEOSTATIONARY OPERATIONAL ENVIRONMENTAL SATELLITE INSTRUMENTS.

The GOES ground-system calibration processing was modified to accommodate the changes in spectral locations and field-of-view sizes of the Imager channels that became effective with GOES-12. Additional processing changes are being developed to accommodate the further changes that will be made to the Imager on GOES-N. The most notable of these is a tenfold increase in the time the Imager spends viewing its blackbody for calibrating its infrared channels. The increase is intended to improve calibration precision.

On Nov. 24, 2003, the operational calibration processing in the GOES Imager's infrared channels was modified to deal with artificial depressions in measured brightness temperatures that occurred in the hours near local midnight. These depressions, reaching a maximum of approximately 1K (for a scene at 300K), were most pronounced in the infrared channels at the shortest wavelengths. We believe they were caused by effects of solar heating in the calibration measurements. The processing modification, which invokes a statistical technique to calculate the calibration coefficients near midnight, succeeded in minimizing the artificial brightness-temperature depressions. In addition to calibration, the product processing algorithms for several products will have been modified to accommodate the new channel configuration.

FY 2004 saw considerable progress in the on-orbit calibration of the Imager's visible channel. This channel, lacking an on-board calibration device, can only be calibrated vicariously, i.e., with targets external to the satellite. Here we report results from two such targets. From eight years of observations of a stable Earth target (the Grand Desert in Sonora, Mexico), we estimated that the responsivity of the GOES-8 Imager's visible channel degraded an average of 5.8 percent per year. From routine observations of approximately 60 stars, we estimated visible-channel responsivity degradations of 4.86 0.08 percent for the GOES-8 Imager (from 10/19/95 to 4/1/03) and 5.56 0.18 percent for the GOES-10 Imager (from 1/4/01 to 11/6/03). The difference between the GOES-8 degradation rates from the two methods is a topic of current research.

More information on GOES calibration topics, including the GOES-12 Imager channel changes, the correction for the midnight infrared-channel calibration errors, and the star- and desert-based vicarious calibrations of the visible channel, can be viewed at http://www.oso.noaa.gov/goes/goes-calibration/index.htm

PATHFINDER.

Climate data sets of cloud amount, aerosol optical thickness (AOT) over the oceans, and the Earth's radiation budget for clear and cloudy skies have been retrospectively generated from over 17 years of AVHRR data as part of the NOAA-NASA Pathfinder program. An improved data set spanning the period from July 1981, through the end of 1999, was completed in 2000. This data set is being used to study the relationship between the variation in global mean values of the absorbed solar radiation and variation in aerosol amount caused by major volcanic eruptions. The influence of the aerosol amount on variations in the global surface temperature is also under investigation. The analysis of time series of anomalies of the cloud radiative forcing has been shown to correlate well (spatially and temporally) with El Niño events. A second reprocessing of the entire data set is being proposed, where multiple-layered cloud data will be used. Land surface and ocean products such as the vegetation index and the sea surface temperature will be added.

OCEAN SURFACE WINDS.

Calibration and validation studies are performed by ORA for all new operational ocean surface wind data streams. Product refinement and development activities are currently underway to improve ocean wind vector retrievals in the high wind speed regime, as well as precipitation regimes, where current retrieval algorithms underestimate the wind speeds. There are several satellite-based active and passive microwave sensors planned for launch in the near future from which NOAA would have the opportunity to obtain near real-time data streams. One of these sensors will be the first demonstration of the passive polarimetric technique, which is being relied on in the NPOESS design to meet the nation's ocean surface wind vector requirements.

HIGH-RESOLUTION COASTAL WINDS AND STORM SIGNATURES FROM SYNTHETIC APERTURE RADAR.

ORA scientists are currently developing techniques for deriving high-resolution (1 km or less) winds from synthetic aperture radar (SAR) imagery, and using these derived winds to study ocean surface wind signatures of atmospheric fronts and storms. By sensing variations in ocean surface roughness on the centimeter scale, SAR sensors can image storms, atmospheric waves (such as mountain lee waves), island and mountain wakes and vortex streets, gap flows, atmospheric fronts, and barrier jets. Application demonstrations are currently underway to provide high-resolution winds, imagery, and other SAR-derived products to operational agencies for evaluation. By the year 2007, there will be as many as five wide-swath SAR satellites. If data acquisition and sharing arrangements can be established to obtain access to SAR imagery from these new sources, frequent routine SAR coverage of U.S. coastal areas will be possible. This increased coverage will allow use of SAR-derived marine and atmospheric products for operational purposes.

OCEAN COLOR.

Several programs at ORA are involved in satellite ocean color research. The Marine Optical Buoy (MOBY) Project develops, deploys, and maintains the MOBY off of the coast of Lanai, Hawaii, to measure visible and near-infrared radiation entering and emanating from the ocean. The resulting measurements support the initialization and vicarious calibration of international and national ocean color sensors, such as the Ocean Color and Temperature Sensor, the Sea-Viewing Wide-Field-of-View Sensor, and the recently launched Moderate Resolution Imaging Spectroradiometer.

The Marine Optical Characterization Experiment (MOCE), MOBY's sister project, involves the collection from ship of in-situ measurements of these and other parameters relevant to ocean color in the surrounding region. Data from both sampling platforms furnish time-series of bio-optical measurements that is employed to track sensor drift, define bio-optical relationships, validate satellite-derived products, and develop ocean color algorithms. In addition to MOBY and MOCE, programs exist at ORA to routinely evaluate the accuracy of NESDIS operational ocean color products and to develop algorithms for remotely

detecting and predicting the presence of noxious marine biota, such as harmful algal blooms.

CORAL REEF WATCH: NOAA'S EARLY WARNING SYSTEM FOR CORAL REEF HEALTH.

Like the rest of the world, most of the U.S. coral reef systems are threatened due to pollution, over-fishing, and thermal bleaching. This threat includes almost all of Florida and Puerto Rico reefs, nearly half of Hawaii's reefs, and an unknown, but significant, fraction of reefs in the U.S. Pacific Territories. The widely distributed and isolated locations of many coral reefs preclude normal monitoring practices. In 1998, NESDIS established an experimental capability using POES satellites to conduct thermal bleaching surveillance of coral reefs on a world-wide basis. This experiment demonstrated remarkably accurate capabilities for early warning of thermally-induced coral reef bleaching conditions over all global tropical ocean regions, resulting in a series of special International Workshops on Satellite Monitoring of Coral Reefs being convened in June 1999, January 2001, and June 2003. In 2002 NESDIS successfully transitioned two existing experimental satellite reef health monitoring products into viable operational web-based products, in particular the Coral Reef HotSpot, an SST anomalies product, and an accumulated heat stress product. In October 2003, NESDIS declared the experimental coral bleaching monitoring products operational. These operational products include SST anomalies, HotSpots, DHWs and Tropical Indices page, and serve as excellent and useful tool for monitoring the potential coral bleaching events. Operational supports for these coral bleaching products are provided at NESDIS on a 24-hour, seven-day basis.

In addition, the proposed Coral Reef Watch (CRW) program provided support to NOAA's Coral Reef Information Service (CoRIS) promoting U.S. leadership in the emerging global "Virtual Coral Reef Ecosystem Monitoring Laboratory," and continues to provide support solid scientific basis for the development of future monitoring and assessment products and/or capabilities.

COASTWATCH.

NESDIS has responsibility for CoastWatch Program Management. This program managed in conjunction with other NOAA Line Offices, makes satellite data products and in situ data from NOAA environmental buoys available to Federal, state, and local marine scientists and coastal resource managers. Data from the Advanced Very High Resolution Radiometer (AVHRR) on NOAA's polar orbiting spacecraft are collected at Wallops Island, Virginia, and at Fairbanks, Alaska. These data are processed on NOAA computers in Suitland, Maryland, using a set of NOAA-developed multi-channel atmospherically corrected algorithms for determination of SST. Data are then mapped (Mercator Projection) and sectored to predefined coordinates specified for each of the CoastWatch regions. Digital, high-resolution data products (1 km/4 km in a CoastWatch Binary Format) are then passed daily to CoastWatch Regional Nodes in the eastern U.S. (i.e., Southeast, Great Lakes, Northeast, Gulf of Mexico, and Caribbean). For Regional Nodes in the Pacific region, CoastWatch local data acquisition and processing capabilities are in La Jolla, California; Anchorage, Alaska; and Honolulu, Hawaii. The Internet is used as the primary telecommunications pathway for digital data distribution. Once products are delivered to the CoastWatch Regional Nodes they become immediately available for local use. An ever-growing number of Federal, state, and local organizations are establishing a formal relationship with local CoastWatch Regional Nodes for routine timely access to CoastWatch image products. More information about CoastWatch is available on the Internet at coastwatch.noaa.gov/COASTWATCH/. Finally, The CoastWatch AVHRR products have undergone a modernization effort. These products are now in a new format (HDF) and use new processing software which has improved the earth locations of the products. CoastWatch has recently expanded, making available ocean color and ocean surface winds, as well as microwave sea-surface temperature, data and products.

NOAA NATIONAL DATA CENTERS (NNDC)

The NESDIS is responsible for the management of the NOAA National Data Centers (NNDC). The NNDC's consist of three data centers: the National Climatic Data Center (NCDC) located in Asheville, North Carolina, the National Geophysical Data Center (NGDC) located in Boulder, Colorado, and the National Oceanographic Data Center (NODC) located in Silver Spring, Maryland (www.nndc.noaa.gov).

The NOAA National Data Centers were established to be the Nation's primary repository for NOAA data. Since their inception, the role of the data centers has expanded in response to the introduction of new technologies useful to the centers and available to the users. Originally designed to archive only NOAA data, these centers now hold environmental data from a variety of sources, to include other U.S. government agencies, such as DOD and NASA, foreign governments, universities and cooperatives, and numerous commercial research programs.

The three NNDCs are responsible for the Scientific Stewardship of the Nation's environmental data, and developing and operating the associated ingest, monitoring, quality control processing, access, archive, analysis

and assessment, creation of climate data records (CDRs), and other product generation systems in support of their national and international commitments and users. The NNDCs archive and provide access to numerous types of data. Each type of data provides a unique perspective for use in climate, oceanographic, space weather, and other geophysical research. It is often the combination of many of these data sets that lead to new discoveries and products that support activities, such as weather forecasting, risk (hazards-public safety and economic) mitigation, weather impact assessments, and climate assessments and predictions.

Data sets are typically divided into the method of collection: Remote (Satellites), Airborne, and In-situ (surface: land and ocean). In-situ includes radar, radiosonde, manual and automated surface observing systems, fixed and drifting buoys, etc. Observational data must be accompanied by comprehensive and complete station history data, referred to as metadata, as well as other ancillary and auxiliary documentation describing the data processing procedures (quality control and assurance) used prior to and after archiving the data.

Climate monitoring, evaluation, and prediction are critical to economic sustainability and environmental stewardship, as well as planning and responding to the quality of life changes that society will encounter in the 21st century and beyond. The challenge facing the NDCCs is not only ingesting and processing very large volumes of new data, but also the convenient and timely access to the data and information. Millions of paper pages and thousands of feet of microfilm/microfiche of recorded instrument measurements and other information dating back hundreds of years are currently under the stewardship of the NNDCs. Over the past 50 plus years, many observations have been stored in digital form. There is now in place a program to convert analog records to digital form. The process will take many years to complete.

The development of a new generation of satellites over the next ten years {NASA's Earth Observing System (EOS), Next Generation Geostationary Operational Environmental Satellite (GOES), and the Joint (DOD/NASA/NOAA National Polar-orbiting Operational Environmental Satellite System (NPOESS)}, the Initial Joint Polar System (IJPS)/MetOp, and the enhancement of the operational Next Generation weather Radars (NEXRAD) {dual polarization} present major data management (stewardship and customer access) challenges to the NNDCs (Figure 3-DOC-10).

To meet these challenges, the NOAA/NESDIS organization has developed the Comprehensive Large Array-data Stewardship System (CLASS) program that will provide a significant portion, but not all, of the funding resources required to improve and maintain the information technology (IT) infrastructure required to support the mandated scientific data stewardship responsibilities for these incredibly large volumes of data.

NATIONAL CLIMATIC DATA CENTER (NCDC)

The National Climatic Data Center (NCDC) is a designated Federal Records Center. It is the officially designated national archive for weather and climate data and information and is the world's largest archive of climate data. The NCDC produces and maintains numerous data sets, products, and assessments, and services many thousands of customers with data and products worldwide. NCDC operates World Data Centers for both meteorology and paleoclimatology. National and global data sets and assessments are produced that support economic and environmental decisions and plans affected by climate variations and change. The NCDC describes the climate of the U.S. through monthly and annual State of the Climate reports. The NCDC is collocated with the U.S. Air Force Combat Climatology Center and the U.S. Navy Fleet Numerical Oceanography and Meteorology Detachment. These three organizations make up the Federal Climate Complex, which together fulfill much of the Nation's climatological requests.

The vision of the NCDC is: To be the most comprehensive and accessible

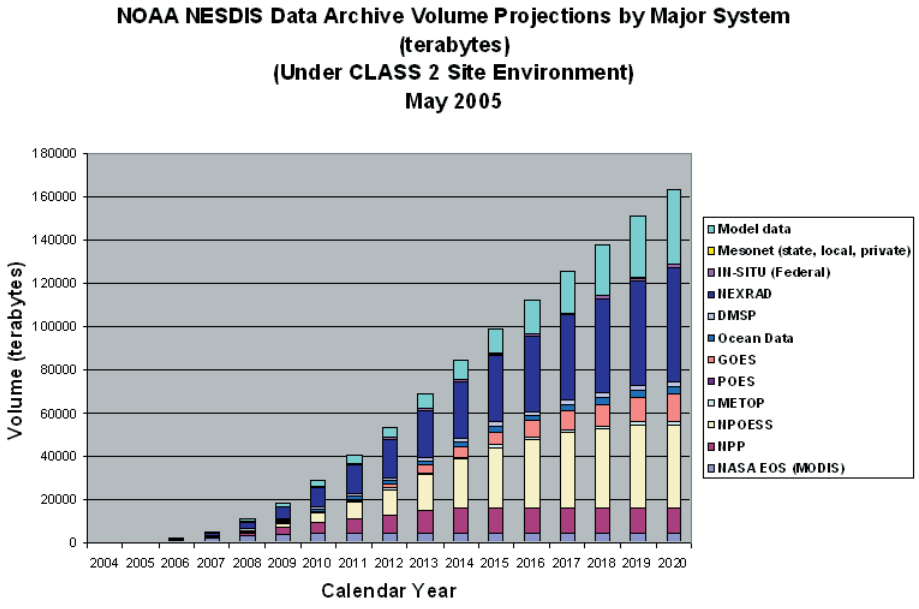


Figure 3-DOC-10. Projected growth of data from major systems that will require processing and storage.

source of quality climate and weather related data and information services and to be an objective authority on climate monitoring.

The mission of the NCDC is: To provide stewardship and access to the Nation's resource of global climate and weather related data and information, and assess and monitor climate variation and change.

The basic functions performed by the NCDC necessary to achieve the mission include: Acquisition (ingest of observations and data) and Quality Assurance Processing, providing Access for new and historical (archived) data, Archiving of data and information (long-term data stewardship), and Assessments (climate monitoring).

The NCDC is the "Nation's Scorekeeper" in terms of addressing severe weather events in their historical perspective. As part of its responsibility for "monitoring and assessing the climate," NCDC tracks and evaluates climate events in the U.S. and globally that have significant economic and societal impacts. Events include drought, hurricanes, tornados, severe storms, flooding, and wildfires. The NCDC is frequently called upon to provide summaries of global and U.S. temperature and precipitation trends, extremes, and comparisons in their historical perspective. Numerous web pages and reports are available dealing with these events and with the "state of the climate" in general. (See http://www.ncdc.noaa.gov/extremes.html and http://www.ncdc.noaa.gov/oa/climate/research/monitoring.html).

The U.S. sustained 62 weather-related disasters during the 1980-2004 period in which overall damages and costs reached or exceeded $1 billion at the time of the event (Figure 3-DOC-11). These disasters do not include any events that had unadjusted damages/losses less than $1 billion dollars, but subsequently may have reached $1 billion after applying the Gross National Product (GNP) inflation/wealth index. Fifty-three of these disasters occurred since 1988 with total unadjusted damages/costs of nearly $260 billion. Seven events occurred in 1998 alone, the most for any year in the summary period, though other years have recorded higher damage totals. (See http://www.ncdc.noaa.gov/oa/reports/billionz.html).

The NCDC developed visualization tools that are used with NEXRAD level II data and NEXRAD level III products. The NCDC NEXRAD Interactive Viewer and Data Exporter load NEXRAD volume scan data and derived products into an OPEN GIS compliant environment. The applications are launched via Java Web Start and run on the client machine while accessing the data remotely from the archive at the NCDC. The NEXRAD Interactive Viewer provides tools for custom data overlays, animations, and basic queries. The export of images and movies is provided in multiple formats. The NEXRAD Data Exporter allows for data export in both vector polygon (Shapefile, GML, Well-Known Text) and raster (GeoTIFF, ESRI Grid, HDF, NetCDF, GrADS) formats. The visualization tools have been used by NASA researchers in studying high atmospheric electronic fields near shuttle launches and by the National Transportation Safety Board in the investigation of aircraft accidents.

Operational Programs:

• Long-term stewardship (archive and access) of the Nation's weather and climate data, as part of the Federal Records Retention System. The NCDC is an approved Agency Records Center and operates under the NARA Federal Records Center guidelines and

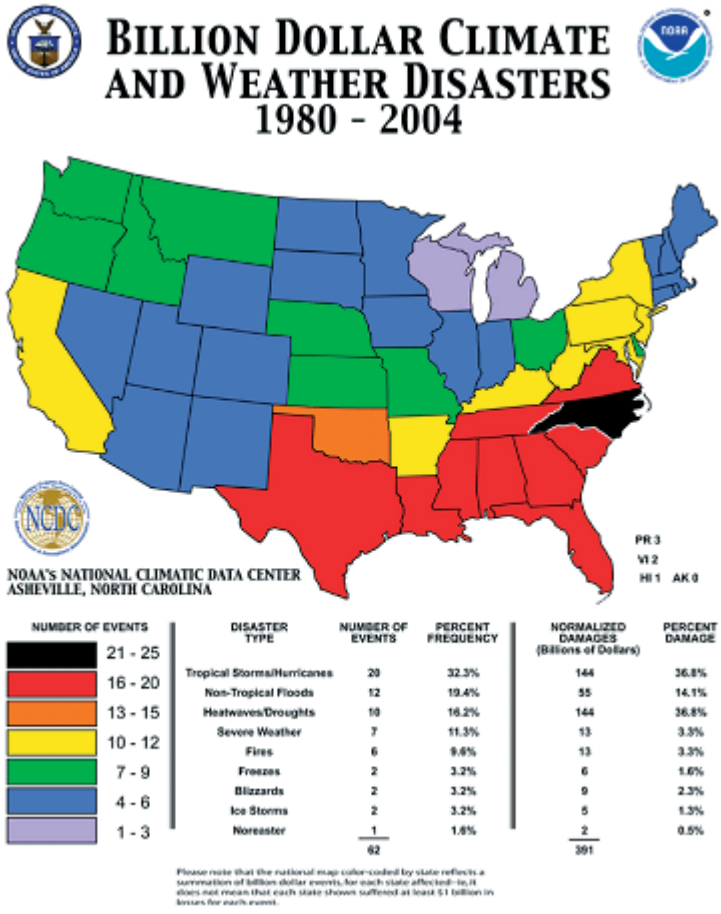


Figure 3-DOC-11. Billion dollar climate and weather disasters (1980-2004) summary.

policies for managing weather and climate data records and information.

• Scientific Data Stewardship functions inherent to the mission of the legislatively designated Nation's Climate Data Center. These include developing and operating the associated ingest, monitoring, quality assessment processing, access, archive, analysis and assessment, creation of climate data records, and other product generation systems in support of national and international commitments.

• National partnerships with Federal agencies (such as the National Aeronautics and Space Administration, Department of Defense, Environmental Protection Agency, Department of Agriculture, Department of Energy, Department of State, National Science Foundation, U.S. Geological Survey, U.S. Global Climate Research Panel), many state agencies, all NOAA Line Offices, Regional Climate Centers, State Climatologists, universities, and many others. These partnerships contribute to the collection, quality assurance processing, and access to regional and national observing networks, to climate monitoring, to the national climate assessments, and to a National Climate Services Program.

• International partnerships with the World Meteorological Organization, International Council of Scientific Unions, World Data Centers, Intergovernmental Panel on Climate Change, UNESCO, and other nations through bilateral and multilateral agreements. Examples are the World Data Center for Meteorology (archiving the data collected by internationally sponsored research programs and actively exchanging climate data with foreign countries to support research and other activities) and the World Data Center for Paleoclimatology (assembling, archiving, and providing access to global paleoclimatic data derived from worldwide tree-rings, stalactites and stalagmites, coral samples, pollen and macro-fossils, lake and bog sediments, marine sediments, ice cores, and other geological and biological sources).

• Maintaining and updating national and global baseline data sets and climate data records that are used for monitoring, evaluation, analyses, and assessments of climate variation and change on global and regional scales. Examples of these data sets include the Global Historical Climatology Network, the U.S. Historical Climatology Network, the Comprehensive Ocean-Atmosphere Data Set, the Comprehensive Aerological Reference Data Set, and the Monthly Climate Data of the World.

• Customer Service. Customers can access data, information, and products through a variety of means, such as real-time and near real-time digital access and retrieval of new and archived historical observations through E-Commerce web enabled capabilities (Internet), as well as through traditional methods, i.e., telephone, e-mail, , facsimile, and traditional post. Digital access, retrieval, and delivery of data on-line and in a robotic storage system via the Internet is the primary and preferred customer service capability. Data and information can also be delivered on magnetic media (tape and disk), hard copy (paper and microfilm), electronic downloads, and staged for FTP transfers. Many of the NCDC assessments, peer reviewed journal articles, published papers, and conference reports are also available on-line.

• Climate Data On-line (CDO) System. The CDO system is NOAA's primary means for distributing and providing access to in situ climate data. CDO includes both recent and historical data, useful for studies of particular weather events and for historical analysis of data for statistical and other research purposes. The general types of data currently included in the system, which continues to be populated, are surface hourly, daily, and monthly data, hourly precipitation data, and 15-minute precipitation data. As data integration efforts continue, the system will be greatly expanded to include numerous additional stations and data types. Also, data summarization and graphing capabilities are being added in 2005. There are two methods to access climate data within CDO:

1) Use the CDO "homepage" - http://cdo.ncdc.noaa.gov - this provides numerous search and retrieval mechanisms, such as by region, country, state, climate division, county, and station; for any required times series.

2) Use the GIS interface - go to http://www.ncdc.noaa.gov and click on "search by map" on the left-hand side bar. The GIS tool-set provides an array of methods to select regions and locations of interest, to overlay various layers of information, etc.

Supporting Research.

The NCDC engages in an active research program to support the operational programs. Examples are:

• Scientific Data Stewardship Program. This program provides an approach to maximizing the performance, quality, and utility of climate observing systems, data, and information so that the scientific integrity and long term utility of climate records for a broad range of users will be ensured. Five fundamental principles provide the framework for this program: (1) ensure Observing System quality during the design phase and real-time monitoring of performance; (2) develop an end-to end Climate Processing System that includes the timely ingest, quality assurance processing, immediate access to new and long-term access to historical records, and the long-term safeguarding of the climate records for future generations; (3) provide basic Information Technology (IT) support; (4) document Earth System Variability through monitoring and evaluation of present, future, and past observations; and (5) enable and facilitate future research through periodic analysis and assessment of new and

historical records.

Research activities supporting this program include:

• Digital Access and Retrieval of Data and Information. Significant progress has been made to digitally ingest data in near real-time and make these data available to users within hours, instead of days or weeks, from on-line disk and robotic tape storage systems. Improved access to the Next Generation Internet high-speed communication capabilities have accelerated the amount of data delivered directly from the field to the NCDC at the time or soon after the time of observation. Data are now available from 10 to 400 times faster than ever before. One example of a very successful NWS/NESDIS/NCDC and OAR collaboration is the real-time direct digital ingest and access to NEXRAD (Weather Surveillance Radar-88D) Level II data through NGI connections with about 128 NWS and DOD sites. The NCDC also receives on a near real-time daily basis digital NEXRAD Level III data from a NWS Central Collection facility. New and historical data are now accessible digitally by users from on-line disk and robotic tape storage systems, and a visualization tool is also available.

• Digital Health of the Network Monitoring (Observing System Performance Indicators). The purpose of the network monitoring process is to improve the quality of new observations and the fidelity of the historical archives by providing real-time information on the health and status of NOAA's observing networks (Figure 3-DOC-12). The fully developed system will continually monitor and assess the state of these networks with the intent of providing feedback that could either lead to improvements in the network or changes in analysis techniques to account for problems in the network. Anomalies and systematic performance problems are evaluated and reported to the network manager. The outcome will be improved observing system performance and higher quality data records. In most cases, these data quality issues can be identified and corrected before the data are incorporated into the historical archives and associated databases. The COOP Observing Network and the U.S. Climate Reference Network (USCRN) are regularly monitored and the plan is to add other networks, such as ASOS, Upper Air, etc. The USCRN program has a more rigorous operational daily monitoring system of hourly performance (See www.ncdc.noaa.gov/oa/hofn/global-insitu.html).

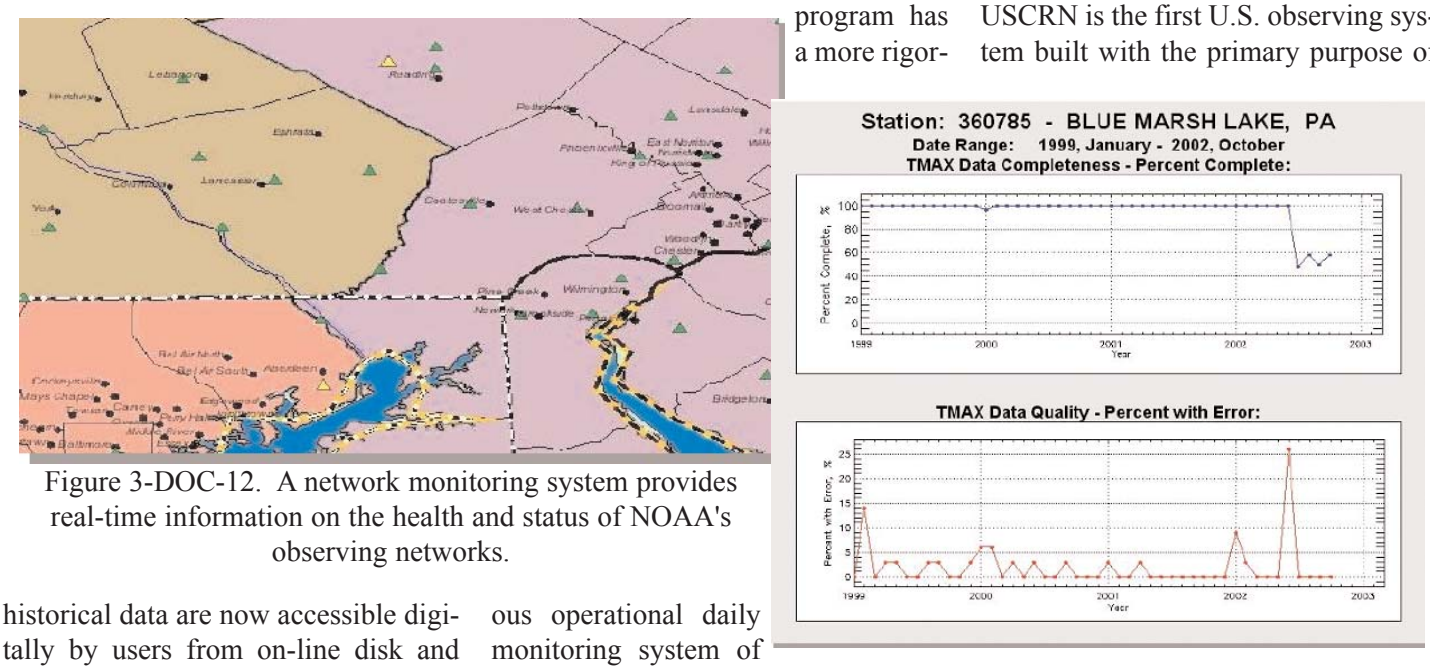


Figure 3-DOC-12. A network monitoring system provides real-time information on the health and status of NOAA's observing networks.

• Assessments and Reports. A series of regular reports are released regarding several key climate issues of concern to the nation. For example, the NCDC releases a monthly and annual State of the Climate for the U.S. and the North American Drought Monitoring Report which is a collaborative effort between Canada, Mexico, and the U.S. (See www.ncdc.noaa.gov/oa/climate/research/monitoring.html). Continuing study of the identification and blending of key parameters from satellite, radar an in-situ observing systems will lead to a new generation of quality climate data records. Understanding and knowledge, as well as new products and services for research and practical economic and environmental uses, will be derived from this progressive approach to maximizing the true value of observations.

• U.S. Climate Reference Network (USCRN). The Ten Climate Monitoring Principles described in the National Research Council Report, Adequacy of Climate Observing Systems (1999), are being used to guide the design, deployment, and life cycle management of the USCRN. The USCRN is the first U.S. observing system built with the primary purpose of providing climate-quality measurements (Figure 3-DOC-13). Data from the fully deployed network of approximately 110 stations will quantify the

variance in surface air temperature and precipitation on a national scale. The USCRN climate-quality observations avoid the time-dependent biases typically experienced with other surface observing networks. The USCRN is becoming the Nation's benchmark network, by providing a standard to which satellite, weather radar, and other surface systems (e.g., ASOS, COOP, mesonets, etc.) observations can be validated and verified. In essence, the USCRN is providing the means to enhance the quality and confidence in other observations, as well as contribute to rehabilitating existing historical databases and data sets. This will produce a significant increase in the volume of climate quality data and information that can be used in assessing past climate trends and change, as well as contribute to the present and future climate monitoring, evaluation, and forecast tasks. (See www.ncdc.noaa.gov /crn.html)

• NOAA Operational Model Archive and Distribution System (NOMADS). NOMADS is a collaborative approach to provide access and data analysis capabilities for model and other data (Figure 3-DOC-14). The NCDC, in partnership with the National Centers for Environmental Prediction and the Geophysical Fluid Dynamics Laboratory, initiated this project to address a growing need for remote access to high volume Global Climate Model and Numerical Weather Prediction model data. The NOMADS team has partnered with existing and development activities including CLASS, National Oceanographic Partnership Program's, National Virtual Ocean Data System, the Department of Energy's Earth System Grid, and the Thematic Realtime Environmental Data Distributed Services developed through the National Science Foundation. NOMADS is a pilot project that uses a distributed client-server framework of data servers together with emerging technologies to access data stored in heterogeneous formats at geographically distributed repositories. NOMADS provides, for the first time, long-term stewardship of numerical and climate model runs and provides the regional modeling community with the data necessary to initialize local models. NOMADS also provides the tools necessary to intercompare model and observational data sets from around the world. Currently there are nine working NOMADS systems across the Nation serving data in the distributed framework. (See www.ncdc.noaa.gov /oa/model/model-resources.html)

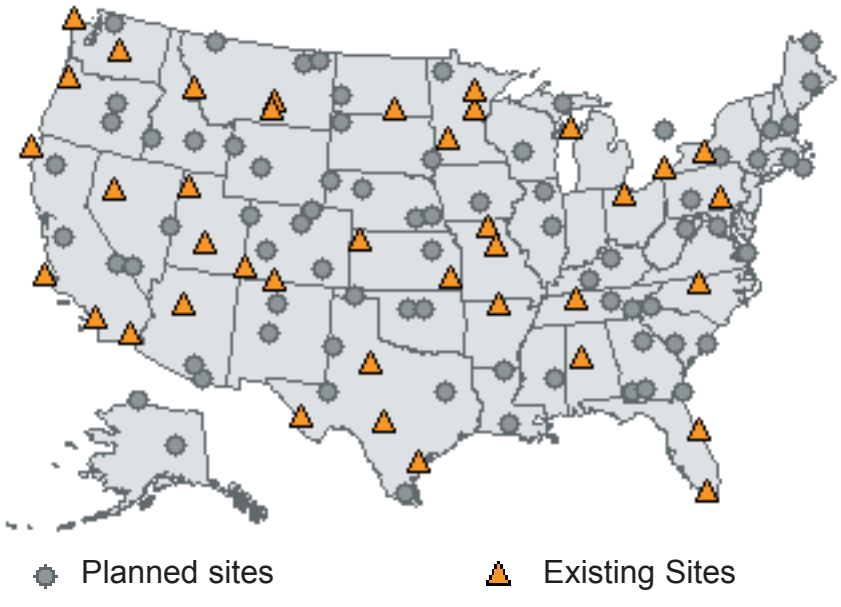


Figure 3-DOC-13. U.S. Climate Reference Network existing and planned sites.

• Climate Database Modernization Program (CDMP). Digital databases of wind speed and direction, precipitation, temperature, and pressure are far more useful than paper and microfilm records. These databases support many disciplines, including economic research, engineering, risk management, and passive (solar, wind) energy enterprises. The CDMP addresses access and utilization issues. The CDMP's goal is to make non-digital (paper/film) historical climate data digitally accessible and retrievable online via the Internet. The conversion of paper and microfilm records to digital databases and data sets will provide access to either optically scanned images of records or data manually keyed into digital databases. Many of these records are being merged with the more recent digital databases extending the digitally accessible and retrievable time series to many decades, as well as hundreds of years in some cases. Forty million documents have been imaged and many thousands of observations manually keyed or digitized from the merchant and military ship records, America's military forts, U.S. cities, lighthouses, weather ships, and other sources. However, approximately two thirds of the paper and film-based climate data remain to be digitized. The CDMP provides an unprecedented and unique opportunity to rescue valuable climate data dating back into the 1700s that are in jeopardy of permanent loss due to the deterioration of the paper and microfilm media (See www.ncdc.noaa.gov /oa/climate/cdmp/cdmp.html) .

• NOAA Paleoclimatology Program. Paleoclimatic data is an important segment of documenting and reconstructing annual to century scale records leading to climate records dat-

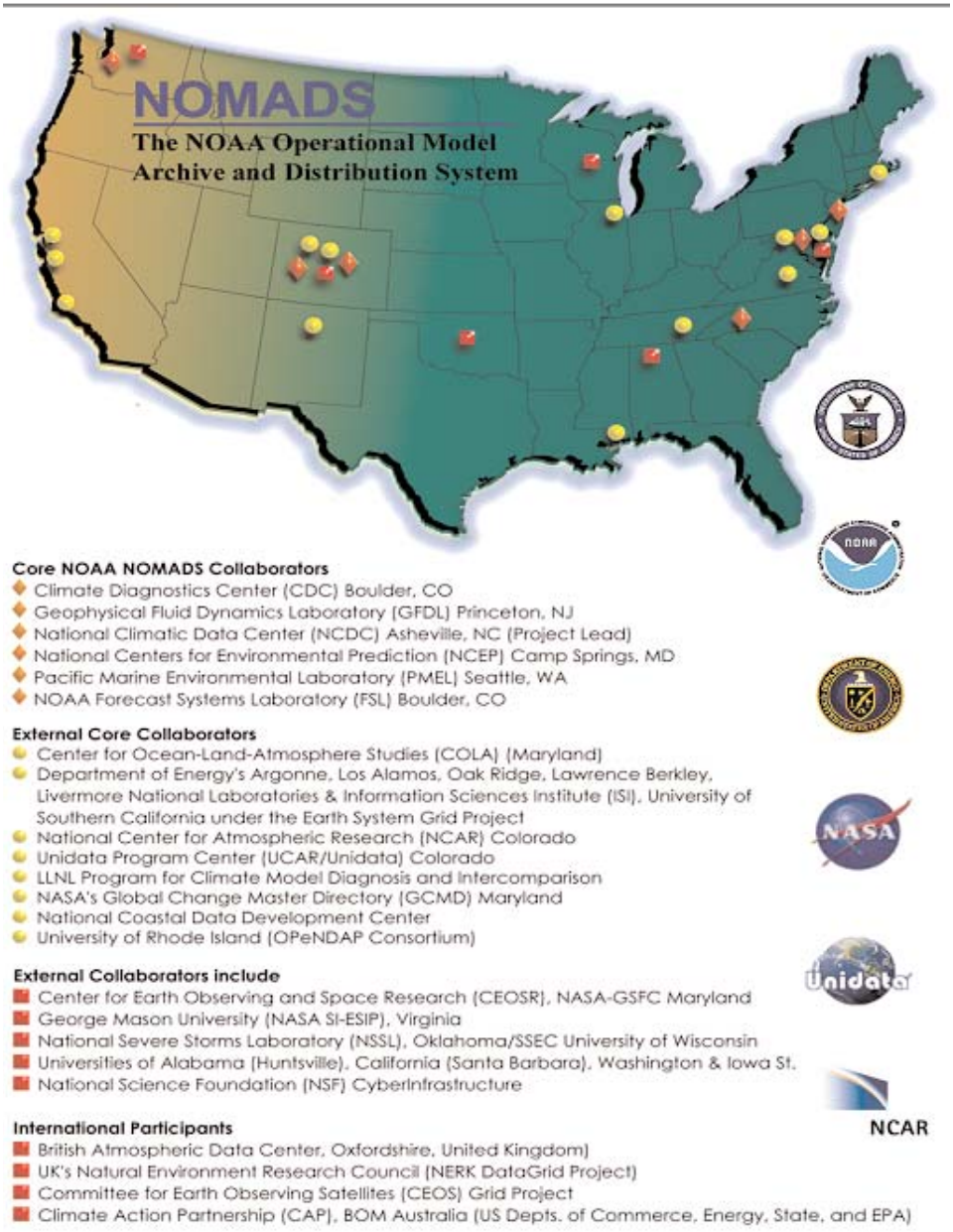


Figure 3-DOC-14. NOMADS is a pilot project and cooperative effort involving six public and private organizations. NOMADS will provide data access and analysis capabilities for model and other data.

ing back tens and hundreds of millennia. The incorporation of this program into the functions and activities of the NCDC enhances the identification and understanding of climate change and variation. The NCDC Paleoclimatology Branch cooperates with many countries in research projects that combine the global paleoclimate database with the instrumental record to extend the climate record back in time for climate model verification and climate change studies. Objectives of the program are to cooperate with researchers in academia, NOAA and other agencies to: conduct original research to describe the global patterns of annual-to-millennial scale climate change, understand the causes of climate change, separate man-induced climate change from natural variability, and validate the models that are used to predict future climates. (See www.ncdc.noaa.gov/paleo/paleo.html)

• Comprehensive Large Array-data Stewardship System (CLASS). CLASS is the NOAA implementation program for an improved architecture for archiving and servicing large-volume data. Advances in technology, including faster network access, web-based interfaces, and emerging discovery and analysis tools, will provide a one-stop capability to access the NOAA large array data sets. The CLASS objective is to establish a web-enabled browse, order, and retrieval delivery system that will enhance and increase the availability and accessibility of satellite, radar, and other data and derived products to customers worldwide. The CLASS integrated storage and web-based access and servicing system design incorporates many of the features and capabilities of the current Satellite Active Archive system built for the POES data stored on a robotic system located in Suitland, MD. The CLASS program has established dual sites, one in Asheville, NC, and another in Suitland, MD. There are plans to move the Suitland site to Boulder, CO, in the second quarter of FY 2006. A third CLASS site is also slated for Fairmont, WV, later in FY 2006.

NOAA Polar-orbiting Environmental Satellite (POES) and Geostationary Orbiting Environmental Satellite (GOES) data are currently available via the CLASS interface. CLASS data and product enhancements will be implemented in phases called campaigns. New major campaigns planned include NEXRAD, National Polar-orbiting Environmental Satellite System Preparatory Program (NPP), National Polar-orbiting Operational Environmental Satellite System, Earth Observing System Long Term Archive, and the European Meteorological Operational Satellite Program (see http://www.class. noaa.gov/nsaa/products/welcome).

• Air Quality Forecasts. NCDC recently began archiving NOAA's Air Quality Forecasts. The Air Quality Forecasts are forecast guidance of one-

hour and eight-hour averaged ground-level (surface) ozone concentration. The guidance will be produced twice a day, for hourly intervals through midnight on the following day (48 model hours), seven days a week for the northeastern U.S. initially, and then gradually will include the entire U.S. by 2009.

The NOAA National Weather Service will provide the data. These data provide ground-level ozone forecast guidance for state and local air quality forecasters and help the public limit adverse effects from poor air quality. This forecast guidance would help meet a congressionally directed national air quality forecast capability. These data will have received a high measure of quality control through computer and manual edits (see www.arl.noaa.gov /ready/aq.html).

NATIONAL OCEANOGRAPHIC DATA CENTER.

The National Oceanographic Data Center (NODC) (www.nodc.noaa.gov) manages the world's largest collection of publicly available oceanographic data. NODC holdings include in situ and remotely sensed physical, chemical, and biological oceanographic data from coastal and deep ocean areas. NODC customers reuse this data to answer questions about climate, and ocean and coastal phenomena. Specifically, NODC data archive and access responsibilities support climate research and operational ocean observing system activities as follows:

• NODC performs ocean profile data management for internationally coordinated global ocean observing systems such as the Argo Ocean Profiling Network and the Global Temperature-Salinity Profile Program (GTSPP) in cooperation with applicable JCOMM committees. NODC's objectives are (1) to safeguard versions of the Argo and GTSPP near real-time and retrospective data and information and (2) to provide high quality data to a wide variety of users in a timely and useful manner. The Argo and GTSPP data system present an excellent opportunity to improve ocean and climate forecasting, with consequent benefits for the protection of life and property and effective planning for the effects of seasonal to inter-annual climate variability.

• NODC produces regular updates of the World Ocean Database and World Ocean Atlas. The most recent version, 2001, includes over seven million profiles of scientifically quality controlled ocean temperature, salinity, oxygen, plankton, pigment, and nutrient data. The Atlas presents statistics and objectively analyzed fields for one-degree and five-degree squares generated from World Ocean Database 2001, observed and standard level flagged data. The ocean variables included in the atlas are: in-situ temperature, salinity, dissolved oxygen, apparent oxygen utilization, percent oxygen saturation, dissolved inorganic nutrients (phosphate, nitrate, and silicate), chlorophyll at standard depth levels, and plankton biomass sampled from 0 - 200 m depth. Further information on both products are available at: www.nodc.noaa.gov /OC5/indprod.html.

• The NOAA Marine Environmental Buoy Database (http://www.nodc.noaa.gov /BUOY/buoy.html) is one of the largest and most frequently used data archives maintained by the NODC. This database holds wind, wave, and other marine data collected by the NOAA National Data Buoy Center (NDBC) from moored buoys and C-MAN (Coastal-Marine Automated Network) stations. Parameters reported by both buoys and C-MAN stations include air temperature and pressure, wind speed and direction, wind gust, and sea surface temperature.

• NODC is developing a capability to provide public access to consistently-processed, climate-capable satellite data sets and applying them to various scientific problems. The first products provided in 2003 were Pathfinder reprocessed 9 km and 4 km sea surface temperatures. For further information see www.nodc.noaa.gov/sog/.

NOAA/NODC LIBRARY

NODC houses the NOAA Central Library (www.lib.noaa.gov/) which supports weather and climate research programs by providing a variety of information services, including:

• Access to print and electronic versions of American Meteorological Society journals.

• Access to Meteorological and Geoastrophysical Abstracts (desktop access at the Silver Spring campus).

• Desktop access to Web of Science at several NOAA sites.

• Assistance in obtaining site licenses for 169 National Weather Service field sites for electronic access to Monthly Weather Review and Weather and Forecasting.

• Archival of historic collections of the Weather Bureau.

• Data rescue of hundreds of volumes of meteorological data publications in danger of loss.

NATIONAL GEOPHYSICAL DATA CENTER

National Geophysical Data Center (NGDC) (www.ngdc.noaa.gov) staff archive, assess, and provide access to satellite and ground-based observatory data from national and international programs supporting research in meteorology, climatology, and space weather as well as solar-terrestrial physics, snow and ice, marine geology and geophysics, and solid earth geophysics. The National Snow and Ice Data Center (NSIDC) is an affiliated partner with NGDC. World Data Centers for Solar-Terrestrial Physics, Marine Geology and Geophysics, , Glaciology, and Solid Earth Geo-

physics under the auspices of the International Council of Scientific Unions are operated by the two national centers. NGDC also hosts the secretariat for the Scientific Committee for Solar-Terrestrial Physics. Research activities focus on satellite remote sensing to assess the long-term changes of the land surface, the space environment, snow cover, and sea ice.

Long-term archive responsibilities for the Nation are provided by NGDC activities. NGDC maintains the Nation's archive for global tsunami and related hazard events. This includes tsunami events, triggers, run-up locations and heights, damage descriptions and photographs. This information is essential for researchers focusing activity on at-risk areas. As part of NOAA's effort to improve tsunami research and warning, NGDC is establishing the long-term archive for ocean bottom pressure and Deep-ocean Assessment and Reporting of Tsunamis (DART) data. NGDC also manages the sole archive of space weather data from GOES, POES and DMSP satellites. NGDC maintains the only archive of raw data records and VNIR imagery collected on DMSP satellites for meteorological, oceanographic and Earth surface studies. The space weather ground-based archives focus on data used in NOAA's space weather forecasts, warnings and alerts. NSIDC manages cryospheric data from both ground-based and satellite instruments. These data stewardship and scientific stewardship activities for satellite and ground-based data include processing, management, analysis and quality assessments.

On line access services to these large databases continue to evolve at NGDC. Data discovery, browsing, and delivery are fairly mature functions. Data directories are managed by relational database management systems available to most search engines. Almost all of the data sets reside in robotic libraries and are accessible online, however some data sets are easier to browse, display and use than others. NGDC recently established Web map-based access to the integrated hazards databases. Users can select events either through the map interface or via a traditional form search and retrieve tsunami event, run-up, earthquake, photographs, and death and damage reports. NGDC has several projects as part of the NESDIS program to digitize and make accessible the most important records in the huge historical archive. Interactive displays of multi-disciplinary data sets and data mining are under development and NGDC has embarked on an environmental scenario generator project to mine information from the archives and to use the mined information to launch a numerical simulation of the atmospheric and space environments.

DMSP program prepares calibrated and geo-referenced records from the raw data records recorded by the scientific instruments on DMSP satellites. Data sets include visible, infrared and microwave imagery, microwave soundings and in situ measurements of the space environment. User services are provided through the Space Physics Interactive Data Resource (spidr.ngdc.noaa.gov/spidr/). Research activities focus on the use of the visible and infrared imagery recorded at night, a unique monitoring capability of DMSP satellites. Starting in 2004, a major effort was undertaken to digitize the nighttime visible imagery to record changes in population and economic vitality over the 30 years of the archive.

GOES, POES and DMSP satellite data of solar activity and the near Earth space environment managed by NGDC provide the long-term monitoring of space weather conditions. These data record the Earth's magnetic field, the electrically charged environment, and solar x-rays from geosynchronous and polar sun-synchronous altitudes. Data from ground-based observatories recording solar activity, ionospheric characteristics and geomagnetic variations complement, enhance and provide ground truth for the satellite measurements. Solar Geophysical Data containing solar and space weather data is published monthly. The space weather program at NGDC archives measurements of total solar and solar spectral irradiance for use in climate studies (http://spidr.ngdc.noaa.gov/ spidr/). Tabular listing of ionospheric parameters and ancient solar images are part of the digitizing and access program.

NATIONAL SNOW AND ICE DATA CENTER.

The National Snow and Ice Data Center (NSIDC) at the University of Colorado, which is affiliated with NGDC, manages several cryospheric-related data archives of interest to meteorology and climatology. These data sets include a collection of historical photographs of glaciers, temperature, pressure and position data from drifting buoys placed on the central Arctic pack ice, and data from the NOAA snow cover and DOD-NOAA sea ice chart digitizing projects. NSIDC provides data management services for a variety of cryospheric research programs sponsored by NASA and NSF. In addition, NSIDC has developed gridded sea ice products (sea ice concentrations and multi-year ice fraction) based on passive microwave data collected by NASA and DMSP satellites. NSIDC is acquiring snow cover, glacier and sea ice records from the former Soviet Union. Online services are available at www.nsidc.colorado.edu (Figure 3-DOC-15).

SUPPORTING RESEARCH.

Natural Hazards Reduction.

Severe tsunami events are relatively rare and frequently the first reaction to a serious event such as the December 26th Indian Ocean tsunami is to clean-

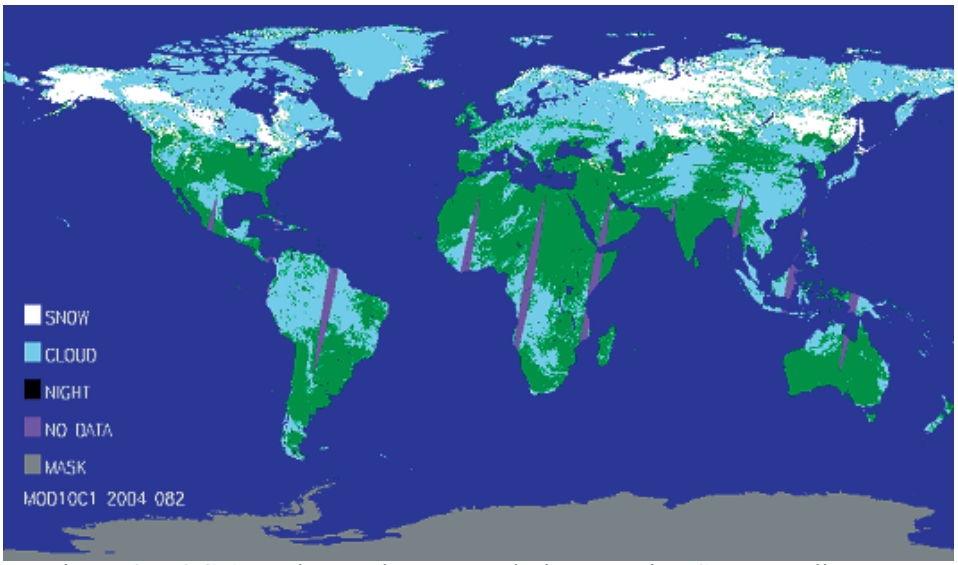


Figure 3-DOC-15. The Moderate Resolution Imaging Spectroradiometer (MODIS) onboard the NASA Earth Observing System of satellites is used to map snow and ice. The figure above is an image from the MODIS/Terra Snow Cover Daily L3 Global 0.05 degree CMG data set (www.nsidc.org).

up the damage. A global database of past tsunami events, run-up heights, death and damage descriptions, and photographs is an essential research tool when identifying at risk areas and likely damage from modeled events. NGDC maintains the nation's global tsunami event database. We are collaborating with Humboldt State University on two projects. The first is to review the completeness and accuracy of the Pacific events reported in the database, extending to include paleo-tsunami events. The second is to develop a framework for analyzing the socio-economic impact of tsunamis. See http://www.ngdc. noaa gov/seg/hazard/hazards.shtml

Environmental Remote Sensing.

Operational meteorological satellite systems provide a unique opportunity to monitor features on or near the Earth's surface, sometimes on a nightly basis. The DMSP nighttime imagery are used to locate sources of visible and infrared emissions including city lights, lightning, wildfires, flaring gas, and boats. Research projects use the city lights to infer such diverse parameters as population density, economic vitality, and carbon dioxide emissions. More information is available at dmsp.noaa.gov/dmsp.html.

Wildfires Monitored from Space.

DMSP Operational Linescan System imagery offer a unique opportunity to monitor wildfires because each satellite records nighttime visible emissions covering the entire globe each day. Instruments designed to detect clouds also "see" wildfires--many of which burn in very remote areas. NGDC has developed a unique capability to capture the nighttime emissions from both large and small wildfires. The system has been used to assist operationally by the Operational Significant Event Imagery and by firefighters in developing countries. More information is available at dmsp.noaa.gov/dmsp.html.

Space Weather.

The space weather program is dedicated to the long-term archive and analysis of NOAA's space weather data. This year marks the completion of an 11-year space weather climatology, covering the ionosphere, thermosphere and inner-magnetosphere. The project, which is designed similarly to the NCEP/NCAR re-analysis project, provides the user community with a uniform view of key space

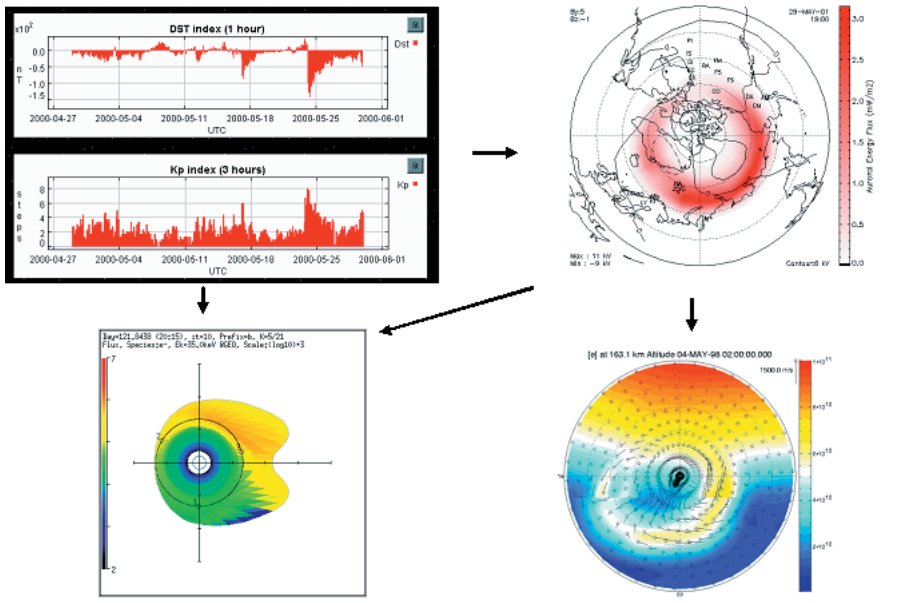


Figure 3-DOC-16. Space Climatology. NGDC researchers use the archive of POES, DMSP, ground-based observatory, and ground-based indices to drive physical models of the near Earth space environment. An assimilation of ionospheric electric fields during the recovery of a major magnetic storm is shown (top right). Physical model outputs for the Earth's magnetosphere (bottom left) and electron density (bottom right) all linked to observational data are shown.

weather domains. In the coming years, analysis of this data will allow for tracking of changes observed in the near-Earth space environment. (Figure 3-DOC-16)

Cryospheric Research at NSIDC.

NSIDC research interests cover a broad spectrum of climate-cryosphere interactions using a variety of observing techniques with special emphasis on arctic regions and satellite-born instruments. Their projects study the long-term record of snow and ice in the arctic, in the sea and in mountainous regions, as well as the hydrology of the southwestern U.S. Algorithms to detect snow, frozen ground and sea ice in passive microwave images recorded on DMSP and NASA satellites have been developed at NSIDC. They have developed models that describe the physical and mechanical properties of snow and ice in glaciers and avalanches. Another area of special interest and study is the interaction between sea ice and the ocean and atmosphere. See www.nsidc.org.

OCEANIC AND ATMOSPHERIC RESEARCH LABORATORIES.

Programs within the Oceanic and Atmospheric Research (OAR) Laboratories support various National Oceanic and Atmospheric (NOAA) meteorological and oceanographic missions. The activities of OAR laboratories are oriented toward providing the scientific and engineering understanding, tools, and techniques that form the basis of improved oceans, weather, water, and climate services.

Special emphasis is placed on improving severe weather, flood, and hurricane warnings and forecasts and on improving the utilization and dissemination of data and information. Severe weather events include flash floods, strong winds, thunderstorms (including tornadoes, lightning, and hail), heavy snowstorms, extreme cold and heat, drought, and geomagnetic storms. The key contributions to improved hurricane forecasts fall under the "Hurricanes at Landfall" (HL) focus of the United States Weather Research Program (USWRP) administered by NOAA's National Weather Service (NWS). They include more accurate prediction of track, intensity, surface winds, rainfall, and human impacts. Improving flood forecasts fall under the component of USWRP labeled "Improving Quantitative Precipitation Forecasting."

In pursuit of improved utilization and dissemination of data, the OAR laboratories conduct both in-house and cooperative research with other NOAA organizations, government agencies, joint institutes, universities, and the private sector. In addition, OAR laboratories conduct research to improve routine weather forecasts and improve the ability to forecast regional air quality and atmospheric deposition.

A significant focus of OAR in the weather and air quality area is the development of operational testbeds under the auspices of the USWRP. These testbeds are the mechanism through which research is transitioned to operations. It is recognized by the USWRP that since NOAA is one of the forecast mission agencies in the program, and the program goals are predominantly operational ones, its most significant role in the USWRP is to provide the infrastructure and capabilities to efficiently and effectively test research products in an operational environment. The testbeds are the Joint Hurricane Testbed, the Mesoscale Numerical Weather Prediction Testbed, and the Joint Center for Satellite Data Assimilation. These testbeds are operated in partnership with other USWRP agencies.

OAR's role is to provide directed research and operational testing, in partnership with the NWS. In addition, the development of the Weather Research and Forecasting (WRF) modeling architecture, also under the auspices of the USWRP, will provide a common modeling structure to be shared by most of the testbeds and between the research and operations communities. Several OAR laboratories are involved in the WRF development in partnership with the NWS and other USWRP agencies.

OBSERVING TECHNOLOGY.

OAR laboratories in Boulder, Colorado, and one in Norman, Oklahoma, are heavily involved with developing new environmental observing system technologies.

The Environmental Technology Laboratory (ETL) in Boulder, Colorado, develops and evaluates new remote-sensing concepts and systems. This development and the associated environmental research directly support the Nation's forecasting and warning services.

The Forecast Systems Laboratory (FSL) in Boulder, Colorado, takes promising new scientific and engineering technologies from the research arena, helps develop them into mature engineering systems, and transfers these technologies to NOAA operations and the private sector.

The National Severe Storms Laboratory (NSSL), located in Norman, Oklahoma, both develops new remote sensing systems and assists in the transfer of these technologies to the NWS.

FSL Observing Activities.

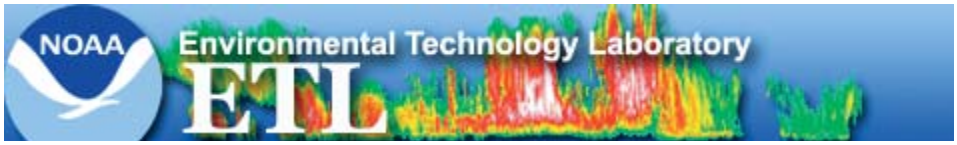
FSL is investigating the use of superpressure balloons in the stratosphere as a platform for monitoring and observing the environment. Among the balloons' capabilities would be atmospheric soundings. The trajectory of the balloons could be controlled to some extent by adjusting their altitude so as to take advantage of the vertical shear. The balloons would carry compact, lightweight sondes whose locations could be tracked as they fell toward the surface. The balloons would comprise a moderately priced global system.

A number of engineering tests have already been performed at altitude by piggybacking on a zero-pressure balloon launched by the Physical Science Laboratory at New Mexico State University and with launches near the Oregon coast. Telemetry was received line-of-sight from a distance of over 200 miles, the storage batteries were charged by solar panels, the proper thermal environment was maintained during the daytime heating cycle, and the instrument package was successfully recovered after descent by parachute.

FSL is also taking a leadership role in implementing the International Earth Observation System includes the development and testing of Remotely Operated Aircraft (ROA, formerly referred to as UAVs) for providing

global weather and climate observations. The FSL is one of several NOAA Research laboratories collaborating with NASA in support of this project. The goal of these missions is to evaluate the utilization of ROAs for improved U.S. and global observing. The Altair's integrated sensor package consists of such components as an ocean color sensor and passive microwave sounder developed by the NOAA's ETL, a gas chromatograph and ozone sensor developed by the Climate Modeling and Diagnostics Laboratory, a digital camera system provided by NASA, and an electro optical infrared sensor provided by GA-ASI. High and medium altitude, long-duration ROAs can fly at remote locations in dangerous flying conditions for long periods. This technology provides many scientific benefits such as sustained global high quality all-weather profiles of atmospheric composition (water vapor, aerosol, cloud water and trace gases), and high altitude vertical resolution and profiling. It also offers a rapid response platform for improved high impact weather forecasts at 1-day to 2-week lead times, and better climate change detection, attribution, and prediction in support of policy decisions.

In a related balloon development effort, the Idaho Falls Division of the Air Resources Laboratory (ARL) is refining its constant-level "smart" balloon, intended to serve as a marker of parcels of air moving across the countryside and permitting samples to be made of the changes occurring in its composition. The Idaho Falls group is also active in the development of high wind speed sensors, such as those used on aircraft and for studies of hurricanes. A specialized probe to measure turbulence during hurricanes is now nearing completion, as a joint project with the Oak Ridge Division of ARL. The Oak Ridge group continues to lead in the development of specialized sensors for measuring atmospheric turbulence. Their systems are now widely used for measuring the efficiency of coupling between the air and the surface, and have recently been selected for instrumenting the latest generation of research aircraft, manufactured in Italy.



ETL Observing Activities.

ETL and FSL will continue development of new sensors and innovative techniques for combining observing systems synergistically and economically. Efforts include developing tools and techniques to integrate the data from surface-based and satellite-borne profiling systems for more effective use of these data in forecasts. In support of this effort, ETL has recently added a satellite remote sensing group that uses data from various environmental satellites to study air-sea interaction processes, the global hydrological cycle including water vapor and precipitation, and the Earth's radiation budget.

ETL has demonstrated that tornadoes can be detected well before touchdown by listening for their unique infrasonic signatures. Infrasonic antennas located in the central U.S. have been used to detect and locate numerous tornadoes. Verification of these tornadoes has been provided by Doppler radar and visual sightings. This research effort is continuing and it is proposed that a network of these inexpensive infrasonic systems be deployed at WSR-88D sites to enhance early detection capability.

Icing is a weather hazard that occasionally causes aviation disasters, especially in winter. In-flight icing forms on wings and other exposed surfaces as an aircraft flies through clouds that contain super-cooled liquid water droplets. Leveraging earlier work with polarization-sensitive cloud radars, ETL designed a new ground-based cloud radar and radiometer system to monitor clouds in the vicinity of airports and to provide automated warnings of icing conditions aloft. This instrument is the Ground-based Remote Icing Detection System (GRIDS). In addition, FSL continues to perform research and analysis to improve aviation forecasts.

ETL is developing an airborne Polarimetric Scanning Radiometer (PSR) designed to provide higher resolution measurements of sea state quantities, including surface winds. ETL is also investigating the possibility of measuring soil moisture by L-band radiometers.

Starting in 2003, ETL and CMDL have been working together establish a new Arctic Atmospheric Observatory in North East Canada as a part of the SEARCH (Studies of Environmental Arctic Change) Program. The Canadian Observatory is being designed to mirror many of the cloud, aerosol and radiation measurements that are already made in Barrow, Alaska. Since North East Canada and Barrow, Alaska are in markedly different Arctic regimes the long-term measurements from these sites will be complementary in providing information to monitor Arctic atmospheric changes. Long-term data from these sites will be used to improve short-term and long-term forecast models, and improve satellite measurement of meteorological phenomena in the Arctic regions.

ETL is engaging in a comprehensive observation program to improve operational weather forecast and planned climate model treatments of boundary layer forcing processes. This work centers on development and application of observing technologies for surface fluxes and key boundary-layer

variables (profiles of temperature, humidity, wind, and cloud properties). Ship-based measurement systems have been developed and are now used routinely on NOAA research vessels to investigate model accuracies in the marine boundary layer. Recently, land-based systems have been developed and deployed. One point of emphasis is linking observed cloud properties (obtained with mm-wavelength cloud radars and microwave radiometers) to cloud effects on surface turbulent and radiative fluxes (this approach is termed cloud forcing). Ship-based and satellite retrievals of cloud and flux properties are being used. ETL is compiling a large data base to allow climatologically-oriented studies of model parameterizations. Future plans include expanding the observational capabilities to add scanning mm-radar capabilities for investigation of precipitation initiation (a critical issue in triggering deep convection in model domains).

The ETL satellite applications group has developed new techniques for monitoring atmospheric properties over the ocean surface including air temperature and specific humidity. Retrievals of these quantities were improved through novel use of satellite atmospheric sounders in combination with passive microwave imaging radiometers. The products are being applied to improved global estimates of the flux of heat between the ocean and atmosphere. ETL is also producing a new satellite-derived sea surface temperature product through the blending of infrared and passive microwave data. The technique takes advantage of the complementary strengths of the two sensor types. The product has significant meteorological applications through its use as an input to numerical weather forecast and climate models.

NSSL Observing Activities.

The NSSL is known for its development of observational capability, both remote and in situ, and in particular for its role in the development of the WSR-88D NEXRAD radar. NSSL is presently working to improve the WSR-88D software algorithms used by the NWS forecasters and is exploring ways to enhance the WSR-88D hardware using dual polarization techniques. Most weather radars, including the WSR-88D NEXRAD radar, transmit radio wave pulses that have a horizontal orientation. Polarimetric radars (also referred to as dual-polarization radars), however, transmit radio wave pulses that have both horizontal and vertical orientations. The horizontal pulses essentially give a measure of the horizontal dimension of cloud (cloud water and cloud ice) and precipitation (snow, ice pellets, hail, rain) particles while the vertical pulses essentially give a measure of the vertical dimension. Since the power returned to the radar is a complicated function of each particle size, shape, and ice density, this additional information results in improved estimates of rain and snow rates, better detection of large hail location in summer storms, and improved identification of rain/snow transition regions in winter storms. The first step in the processing is to prototype a new Radar Data Acquisition (RDA) unit for the WSR-88D capable of processing the additional information to produce the dual polarization information. In March 2002, dual polarized data were collected using the NSSL WSR-88D research radar located on the NSSL Norman, Oklahoma campus. NSSL is assisting the NWS with the next step, the development of a generalized dual-polarization solution for their network of WSR-88D radars.

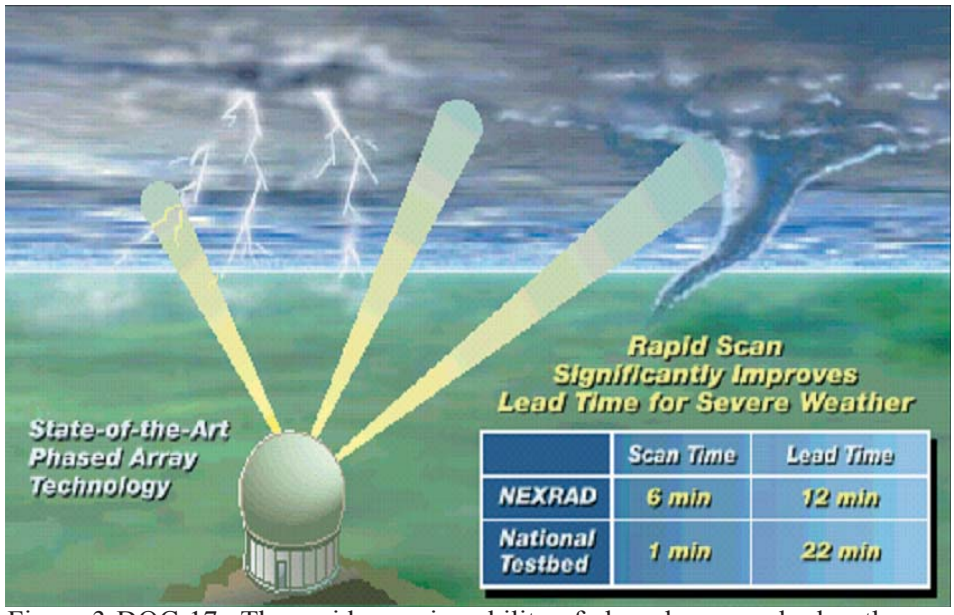


Figure 3-DOC-17. The rapid scanning ability of phased array radar has the potential to significantly increase the average lead times of tornado warnings.

NSSL researchers are adapting SPY-1 radar technology currently deployed on Navy ships for use in spotting severe weather (Figure 3-DOC-17). Early tests and data collections from the phased array radar system have proved promising, and the technology has the potential to improve the NEXRAD system for all weather radar applications. Using multiple beams and frequencies that are controlled electronically, phased array radar reduces the scan time of severe weather from six minutes for NEXRAD radar to only one minute, producing quicker updates of data and thereby potentially increasing the lead time for tornado warnings well beyond the current average of 11 minutes. Other NSSL developed technology will extend lead times even farther.

HIGH IMPACT WEATHER RESEARCH

The NSSL focuses on research to better understand severe weather systems and their associated hazards, such as tornadoes, hail, high winds, heavy rain and snow, lightning, and ice storms with the goal of helping the NWS improve forecasts and warnings. The parameters of storm development and intensification are identified and studied by incorporating observations from Doppler weather radar, satellites, remote-sensing wind profilers, instrumented aircraft, and lightning-location networks. NSSL's research includes assessment and improvement of numerical models to forecast severe weather systems.

NSSL provides significant technical and scientific support, with a focus on research and development, for the NWS WSR-88D radar program. In 2005, NSSL continued to develop techniques, in cooperation with the NWS, to forecast and warn of weather hazards to aviation and the general public. The Joint Polarization Experiment (JPOLE) was conducted in the spring of 2003, with the overarching goals of testing the engineering design and determine the data quality of the polarimetric KOUN WSR-88D radar, demonstrating the utility and feasibility of the radar to operational users, and collecting data and information that could be used to perform a cost/benefit analysis. Knowledge gained from the Verification of the Origins of Rotation in Tornadoes Experiment (VORTEX) campaigns in the mid- and late-1990's, 1998's Mesoscale Convective System (MCS) Electrification and Polarimetric Radar Study (MeaPRS) and the 2000 Intermountain Precipitation Experiment (IPEX) provided new understanding of severe thunderstorms, storm electrification, winter weather, and tornadoes and led to improved methods to detect, model, and predict these storms (Figure 3-DOC-18).

NSSL works closely with the NWS WSR-88D Radar Operations Center (ROC). NSSL's involvement with the project to re-host the Radar Product Generator to an open systems computation platform (ORPG) was completed in November 2001. The ORPG system will ease the incorporation of new software applications and allow for integration of new hardware technology into the radar system resulting in less time needed for technology transfer. The NWS's ORPG deployment for 170 total radar sites, both operational and non-operational, began August 2001 and ran through 2002. In 2004 and 2005, the ROC and NSSL worked together to extend a prototype research project that provided high-resolution Level II WSR-88D radar data to universities, government users, and private companies to a national level.

Improvement of short-range (1-12 hour) forecasting will be accomplished by the development and evaluation of new local data system technologies and techniques, many of which can be incorporated into operational weather forecasting in the near term. FSL develops and evaluates state-of-the-art workstations for forecast office environments. Specifically, FSL has and will continue to develop capabilities to allow the forecaster to integrate, view, and manipulate observations from current and planned meteorological sensing systems using computer-assisted data display and synthesis techniques. NSSL is collaborating with NWS and FSL to integrate some of NSSL's advanced single and multi-radar display capabilities into AWIPS.

FSL will continue efforts toward effective assimilation of diverse observational data into numerical prediction models. Data from the Aeronautical Radio Incorporated (ARINC) Aircraft Communications, Addressing, and Reporting System (ACARS); WSR-88D Doppler radars; and weather satellites, especially Geostationary Operational Environ-mental Satellite (GOES), are frequent and provide unprecedented resolution, either in the vertical or the horizontal, or both. These data are being more fully exploited in the Local Analysis and Prediction System which provides highly detailed analyses and forecasts over areas hundreds of kilometers on a side, and the Mesoscale Analysis and Prediction System, the basis for operational and frequent short-term forecasts for the lower 48 states. The system has been incorporated into the

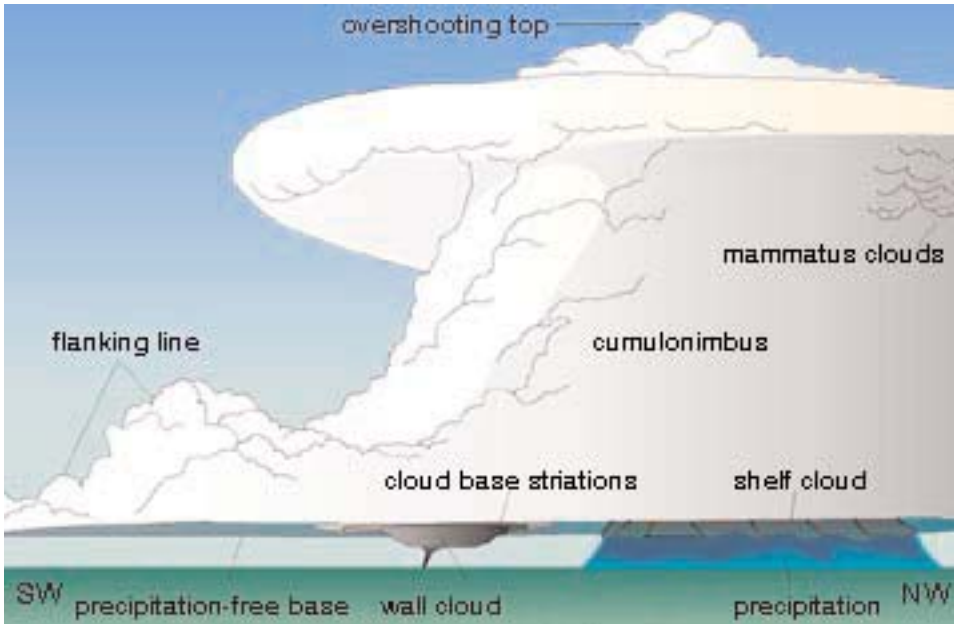


Figure 3-DOC-18. Schematic diagram of a thunderstorm
(Source: NSSL's VORTEX Project web site)

AWIPS system and is being used by a number of other agencies, not only for various regions of the U.S., but for a number of regions throughout the world.

OAR will continue to transfer knowledge of Doppler radar applications, severe weather systems, and heavy rainfall events; much of the transfer is through courses at the NWS training center. Visits and interactions with NWS centers, regional headquarters, and forecast offices continue and NSSL is participating directly in training programs, such as COMET in Boulder, Colorado, and the WSR-88D Operational Support Facility in Norman, Oklahoma.

A multi-year program of coastal meteorology research continues at the Pacific Marine Environmental Laboratory (PMEL). This program also involves ETL and NSSL, the Seattle NWS Forecast Office, the National Center for Atmospheric Research (NCAR), and the University of Washington. Support for the program is also being provided by the Office of Naval Research. This research improves understanding of the effects of prominent terrain on West Coast weather, with the ultimate goal of providing improved forecasts of coastal winds, precipitation, sea state, and storm surges. The emphasis is on the upstream effects of the coastal terrain in the storm environment when the background forcing is strong and the coastal forecasts are most critical. The approach involves special field observations and diagnostic studies using experimental numerical simulations. Field work featuring a NOAA WP-3 research aircraft in the 1990s, for example, has yielded meteorological data for the Pacific Northwest coast with low-level winds of up to 85 knots, in the vicinity of strong fronts and, in one case, an intense, landfalling low pressure system. The case studies from this work provide immediate insights on the influences of the coastal terrain on landfalling storms, and high quality data sets for numerical model initialization and validation. Follow-up field programs in FY 2004 and FY 2005 focused on cloud and precipitation processes using special observations from research aircraft and land-based radars. The results are providing information on how to improve forecasts of storms in the Western U.S. This activity is also coordinated with the NWS Office of Hydrologic Development and NCEP's Climate Prediction center for support to hydrologic resource forecasting to help better forecast floods and droughts.

MESOMETEOROLOGY AND PRECIPITATION FORECASTING AND WARNING RESEARCH

NSSL develops techniques to improve short-term forecasts of significant weather events. Through detailed case studies and regional climatologies, scientists have developed diagnostic tools and aids for operationally forecasting thunderstorms, lightning, flash floods, and large mesoscale convective storms complexes. Experiments such as the Severe Thunderstorm Electrification and Precipitation Study (STEPS) in 2000 were conducted to improve the science behind the technology. STEPS was designed to improve understanding of how severe storms become electrified and to better understand how variations in lightning flash type and flash rate relate to severe storm classification and storm evolution. Other studies underway are focused on the precipitation structure of mesoscale convective systems, the interactions between mesosconvective systems and the larger environment, the use of satellites to infer storm development and rainfall, short-range ensemble forecasting techniques, and winter storm forecasting procedures. Findings from these research activities lead to supporting the forecasting of other high impact weather forecasting events such as heat waves and air quality forecasting.

Figure 3-DOC-19. The OU Doppler-on-Wheels and the NSSL mobile laboratory take measurements of a snowstorm in Idaho during IPEX.

NSSL will continue to investigate various model convective parameterization schemes, along with techniques to improve model initialization through four-dimensional data assimilation in 2002. Also in 2002, NSSL conducted an experiment called the International H2O Project (IHOP). IHOP was a field experiment over the Southern Great Plains (SGP) of the U.S. The chief aim of the 2002 IHOP campaign was improved characterization of the four-dimensional (4-D) distribution of water vapor and its application toward improving the understanding and prediction of convection. The SGP region is an optimal location due to existing experimental and operational facilities, strong variability in moisture, and active convection.

NSSL is working with the NWS Storm Prediction Center (SPC) to improve the nation's ability to forecast severe weather and to enhance severe winter weather guidance products. Data collected during the IPEX campaign held in 2001 should help. The data are being analyzed by NSSL, SPC and University of Utah scientists. The IPEX field and research program was designed to improve the understanding, analysis, and prediction of precipitation and precipitation processes in complex terrain (Figure 3-DOC-19). Data analysis of IPEX continues in 2005.

A crew of NOAA NSSL and National Center for Atmospheric

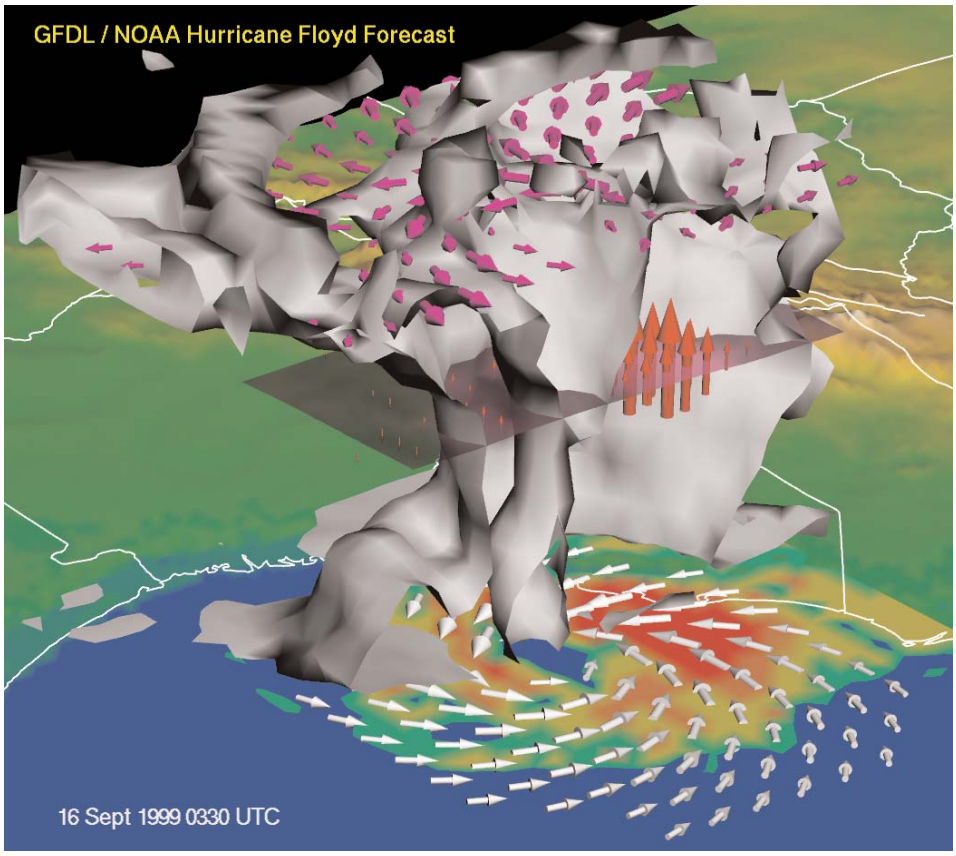


Figure 3-DOC-20. GFDL's 3-D model depiction of Hurricane Floyd

Research (NCAR) scientists and University of Oklahoma and New Mexico Institute of Mining and Technology students and faculty, scrambled to get in position beneath thunderstorms to launch balloons to measure temperature, pressure, humidity, and the electric field profile of storms as part of TELEX, the Thunderstorm Electrification and Lightning Experiment in May and June 2004. The broad objective of TELEX is to learn how lightning and other electrical storm properties are dependent on storm structure, updrafts, and precipitation. This information will point to new ways for the National Weather Service to use lightning observations to improve forecasts and warnings of hazardous weather. TELEX also took advantage of new sensors, the KOUN radar in Norman, a WSR-88D radar modified with polarimetric parameters to provide information about the particle size and water phase of precipitation and the Oklahoma Lightning Mapping Array (LMA). The OK-LMA is a network of ten stations in central Oklahoma that continuously maps the structure of all types of lightning in three-dimensions out to a range of 75 km and in two-dimensions out to a range of 200 km.

Mesoscale Dynamics at the Geophysical Fluid Dynamics Laboratory (GFDL) in Princeton, New Jersey, develops and utilizes atmospheric models with limited spatial domains to understand mesoscale phenomena and the interaction of these regional scale features with the atmosphere's larger-scale synoptic processes. As part of these research activities, GFDL scientists investigate the practical limits of forecast models to predict the behavior of these mesoscale features through model sensitivity studies. (Figure 3-DOC-20).

The FSL implemented a Rapid Update Cycle (RUC) at NCEP in 1994 with periodic follow up upgrades since. The RUC gave a new analysis of surface and atmospheric conditions every three hours as well as short-range predictions for the next 12 hours. This information is useful to forecasters at local NWS offices around the country and also supports commercial and general aviation.

A higher-resolution, higher-frequency version of the RUC was implemented at NCEP in 2005. The 13 km version of NOAA's Rapid Update Cycle (RUC13) model became operational at 1200 UTC Tuesday 28 June 2005, at the National Centers for Environmental Prediction (NCEP). This is a major milestone for improving the RUC high-frequency short-range forecasts for NOAA and external users, especially for aviation and severe weather forecasting.

The main changes include higher horizontal resolution (from 20 km to 13 km), improved data assimilation especially for moisture/cloud fields, and improved cloud/precipitation physics. Most notable improvements are in surface and cloud/precipitation forecasts, resulting in part from assimilation of new observation types in the RUC13. The model updates every hour, incorporating information from virtually all high frequency data sources: hourly wind profiles; WSR-88D (Doppler radar) velocity azimuth displays; ACARS reports (up to 65,000 per day); cloud-drift winds and estimates of total precipitable water vapor from the GOES satellites; and surface observations. The new RUC also includes explicit forecasts of cloud droplets, ice crystals, raindrops, snowflakes, and graupel (snow pellets). This improves the forecast of precipitation type. The RUC exploits a new, multi-level soil and vegetation model to improve forecasts at and near the earth's surface.

Along with NCAR, NCEP, and the university community, FSL is collaborating on the development of a new mesoscale model, the Weather Research and Forecast (WRF) model. The goal is to have the WRF model become a community model and a tool both for experimental and operational

prediction, thus paving the way for quick realization of research advances in forecast dissemination to the public and industry.

The Air Resources Laboratory (ARL) is also involved in the development of new models for operational use by NCEP. The main focus is on mesoscale models and in the development of new capabilities for data assimilation. In particular, the new generation of mesoscale models (such as the WRF model referred to above) will require advanced descriptions of the coupling between the air and the surface, a matter that is being studied intensely in ARL programs involving closely interacting measurement and modeling activities. To this end, ARL maintains the Nation's surface radiation network (SURFRAD), data from which are now routinely employed to test both forecast mesoscale models (such as the Eta model) and satellite outputs. ARL conducts research on the surface energy balance and on the spatial variability of surface fluxes using aircraft. In addition, ARL serves as the provider of the NCEP modeling capability to address situations of atmospheric dispersion, such as of emissions from sources like volcanos, industrial enterprises, and nuclear accidents. In recent work, ARL is developing a new system for forecasting the dispersion of smoke from forest fires, in collaboration with the Association of South East Asian Nations, the U.S. Forest Service, and The Mediterranean Centre for Environmental Studies Foundation.

TROPICAL ATMOSPHERIC RESEARCH

The Tropical Dynamics and Climate Program of the Aeronomy Laboratory (AL) is using precipitation profilers to study the structure, evolution and variability of precipitating cloud systems in the tropics and elsewhere. Precipitation measurements can be made with sufficient vertical resolution to categorize precipitation in deep and shallow convective systems and in stratiform conditions. A recent focus of research with profilers has been to provide ground validation research in support of satellite precipitation measurement missions such as the NASA Tropical Rainfall Measuring Mission (TRMM). These observations have provided important information on the vertical structure and temporal evolution of precipitating cloud systems during TRMM Ground Validation field campaigns. The profiler observations have been made available to the TRMM Science Team and can be viewed on the AL web page (www.al.noaa.gov). The observations made during the field campaigns are the subject of collaborative research with other TRMM researchers with an emphasis on the use of profilers to calibrate scanning radars used for TRMM ground validation research and the use of profilers to retrieve drop-size distributions and related precipitation parameters of interest to the TRMM Science Team. Validation of drop-size distributions used in algorithms is key to improving the retrieval of rainfall estimates from the TRMM satellite data. The profiler-based precipitation research described above also can be used to provide calibration of NEXRAD scanning radars as has recently been demonstrated for Melbourne, Florida. In related activities the Aeronomy Laboratory has teamed with the ETL in hydrometeorological studies in relation to the PACJET campaign on the west coast and also is working with ETL on microphysical process studies utilizing profilers in the North American Monsoon Experiment (NAME).

HURRICANE ANALYSIS AND PREDICTION RESEARCH

The Hurricane Research Division's mission is to advance the understanding and prediction of hurricanes and other tropical weather. HRD's research is based on a combination of models, theories, and observations, with particular emphasis on data obtained with research aircraft. The goals of this research are to:

1. Advance the prediction of tropical cyclone intensity change by improving understanding of the processes that modulate internal storm dynamics and storm interactions with the atmosphere and ocean;
2. Improve the prediction of tropical cyclone tracks by enhancing understanding of the interactions between a tropical cyclone and its environment through an optimal analysis of field observations;
3. Improve the understanding of and ability to predict tropical cyclone frequency and intensity on intraseasonal, interannual, decadal and longer time scales; and
4. Enhance the ability to diagnose and predict the impact of tropical cyclones on life and property through wind, rain, waves, and storm surge.

These goals are accomplished by:

1. Designing and conducting research experiments in the hurricane to collect and provide data for research and applications;
2. Analyzing these data sets and publishing the research in the refereed literature;
3. Developing new technology and applications based on this research to improve NOAA's products; and
4. Providing outreach to the public through the WWW, conferences, presentations, and other means.

Much of HRD's research is based on the in situ and remotely-sensed observations in the inner core of tropical cyclones and their surrounding environment. These observations are primarily collected in our annual field program using the two NOAA turboprop aircraft and jet operated by the NOAA Aircraft Operations Center (AOC). The field program is used to carry out scientific experiments designed to address the goals stated above. Data sets gathered by these experiments, combined with dynami-

cal and statistical models and theoretical development, range from global to microscale, forming the cornerstone of research in HRD. Because of this extensive field experience, HRD scientists are recognized internationally for their knowledge of tropical cyclones as well as their expertise in technological areas such as airborne Doppler radar, dropsondes, cloud microphysics, and air-sea interaction, to name a few. These assets make HRD unique worldwide, and provide NOAA a unique capability.

In 2005, NOAA's HRD begin a multi-year experiment this summer with the NOAA Aircraft Operations Center (AOC) called the Intensity Forecasting Experiment (IFEX). Developed in partnership with NOAA's Environmental Modeling Center (EMC) and National Hurricane Center (NHC), IFEX is intended to improve our understanding and prediction of hurricane intensity change by collecting observations that will aid in the improvement of current operational models and the development of the next-generation operational hurricane model, the Hurricane Weather Research and Forecasting model (HWRF). Observations will be collected in a variety of hurricanes at different stages in their lifecycle, from formation and early organization to peak intensity and subsequent landfall or decay over open waters. There are several unique aspects of IFEX in 2005 that will help improve our understanding and prediction of hurricane intensity change. Some examples are provided below:

Hurricane genesis experiment - Take data to improve our knowledge of the evolution of tropical waves to tropical storms.

SFMR validation - The Stepped-Frequency Microwave Radiometer (SFMR) evaluation of a unique airborne tool that enables the remote measurement of surface wind speeds and rain rates over the water.

Impact of Saharan air on intensity forecast models - Recent research has shown that very dry air originating from the African continent, called the Saharan Air Layer (SAL), may be an important factor in hurricane intensity change.

Doppler Radar - Mapping of the center wind field from airborne tail Doppler radar and its transmission to EMC and NHC in real-time.

High-altitude penetrations of the hurricane's center -The high-altitude NOAA G-IV jet will penetrate the inner core of hurricanes. This capability will be vital once a Doppler radar is installed on the G-IV, enabling the three-dimensional mapping of wind fields from nearly top to bottom of hurricanes.

NSF Hurricane Rainband and Intensity Change Experiment (RAINEX) - The main goal of RAINEX is to investigate interactions between a tropical cyclone's inner core and its associated rainbands, and the role this interaction plays in determining intensity change.

HRD coordinates its programs with other NOAA organizations, e.g., NOAA's Aircraft Operations Center (AOC) and the National Center for Environmental Prediction (NCEP), and in particular with the Environmental Modeling Center (EMC) and Tropical Prediction Center/National Hurricane Center (NHC). HRD maintains active research programs with, and receives funding from other governmental agencies, in particular, the Department of the Navy's Office of Naval Research (ONR) and the National Aeronautics and Space Agency (NASA).

In program areas where it is beneficial to NOAA, HRD arranges cooperative programs with scientists at the National Center for Atmospheric Research, and at a number of universities. The highest priority experiment in 2004 is the Coordinated Boundary Layer Air-Sea Transfer (CBLAST) experiment focused on improving numerical model parameterization of the air-sea transfer of energy that fuels the storms. HRD also integrated two recent NASA field experiments and a fifth Convective and Moisture Experiments (CAMEX-5), is being proposed in 2005. HRD is also working with U.S. and international partners on plans for the African Monsoon Multidisciplinary Activity (AMMA) in 2006.

Currently, the HRD research staff consists of 26 full-time employees and 10 employees working under a cooperative joint agreement with the University of Miami (CIMAS).

Under the USWRP and its participating agencies, OAR, NWS, and NESDIS established a Joint Hurricane Testbed (JHT) at the Tropical Prediction Center in Miami, Florida. It is anticipated that the JHT will continue to grow in FY 2005 as more resources become available. This testbed is where the hurricane research will be evaluated for operational use and those research products passing the test will be handed off to operations.

NUMERICAL ANALYSIS AND PREDICTION MODELING

As part of its weather research activities, GFDL conducts long lead-time research to understand the predictability of weather on both large- and small-scales and to translate this understanding into improved numerical weather prediction models. Three groups at GFDL are engaged in weather research activities: Experimental Prediction, Mesoscale Dynamics, and Hurricane Dynamics.

Experimental Prediction at GFDL develops and improves numerical models of the atmosphere-ocean-land system in order to produce useful weather forecasts with lead-times ranging from weeks to seasons and beyond. The group is pursuing several

avenues of research to achieve such improvements. First, GFDL scientists are investigating methods of stochastic dynamic prediction in order to extract as much forecast information as possible from numerical weather prediction models, given imperfectly observed initial conditions. In addition, laboratory scientists are developing methods for the assimilation of ocean observations into prediction models in order to improve the forecast of the atmosphere and the ocean.

AIR QUALITY RESEARCH

The principal mission of the ARL is to improve the capability to forecast changes in air quality and atmospheric deposition. Deposition is the factor that links the pollutant characteristics of the air with the terrestrial and aquatic environments. ARL's research focuses on the lower atmosphere, where the atmosphere is in direct contact with other media-- aquatic, terrestrial, and biospheric. The core of ARL research relates to studies of the atmosphere as a component of the total environment. Much of this work is in collaboration with other parts of NOAA (principally NCEP) and with other agencies, such as EPA, DOE, and the DOD.

The ARL Headquarters Division in Silver Spring, Maryland, develops models for air quality prediction, for use in special forecasting (both weather and air quality) programs, and in emergency response. The Atmospheric Sciences Modeling Division, in Research Triangle Park, North Carolina, develops predictive models on local, regional, and global scales for assessing changes in air quality and air pollution exposure as affected by ecosystem management and regulations. This work is primarily to provide technical guidance to the EPA on air pollution control strategies for attainment and maintenance of ambient air quality standards. The Atmospheric Turbulence and Diffusion Division, in Oak Ridge, Tennessee, conducts studies to improve understanding of atmospheric transport, diffusion, and air-surface exchange processes, and to develop new predictive models. The Field Research Division, in Idaho Falls, Idaho, designs and conducts field studies to evaluate the performance of transport and dispersion models, over local, regional, and continental scales, and specializes in the development of high-technology airborne instrumentation (for both aircraft and balloons). The Special Operations and Research Division (SORD), in Las Vegas, Nevada, conducts research on problems of mutual interest to NOAA and DOE that relate to the Nevada Test Site, its atmospheric environment, and its emergency prepared-ness and emergency response activities. SORD also serves as the main NOAA facility working with the Cooperative Institute for Atmospheric Studies and Terrestrial Applications (CIASTA) of the University of Nevada system.

ARL operates two national networks that direct research attention on the needs of the next generation of predictive models. The Atmospheric Integrated Research Monitoring Network (AIRMoN) is a nested-network with sites of varying complexity addressing evolving scientific issues of wet and dry deposition from the atmosphere. A major current item for scientific attention is the atmospheric deposition of nitrogen compounds and its role in promoting eutrophication of ecosystems, primarily coastal. The ARL-run Integrated Surface Irradiance Study (ISIS) serves as the national array of monitoring stations for solar radiation (and ultraviolet-B) with a subset of more advanced stations (the SURFRAD array) where both incoming and outgoing radiation components are monitored. Many of the SURFRAD stations are augmented with instrumentation to measure fluxes of sensible heat, latent heat, momentum, and carbon dioxide. Thus, the SURFRAD program is evolving into one of complete energy balance with supporting data on carbon dioxide exchange. This work forms an intersection with the new flux measurement networks in the U.S. and overseas, referred to as "Ameriflux" and "Fluxnet." All of this work is coupled with ARL research on atmospheric aerosols and with the development of new automatic methods for measuring cloud cover.

Much of ARL's research focus is on expressing air surface exchange processes in numerical models. To this end, ARL scientists have been instrumental in developing methods for describing an air surface exchange appropriate for use with model grid cells of several tens of kilometers on a side. To test the aerial integration capabilities, ARL has instrumented an aircraft of the NOAA fleet (a DeHavilland Twin Otter) to measure all of the eddy fluxes as well as a number of trace gas exchange rates. This instrumented aircraft has been used in several field experiments and has already demonstrated that considerable error can result when local values are inappropriately taken to represent larger areas.

ARL also provides forecast support to NOAA's emergency response systems with emphasis on chemical, nuclear, and volcanic events. For this application, ARL develops and couples advanced dispersion models with the forecast products of the NWS to provide a basis for trajectory and dispersion calculations. The models in question are now widely accepted. The Hazardous Atmospheric Release Model (HARM) is operationally employed at a number of DOE locations. The ARL Hybrid Single Particle Lagrangian Integrated Trajectory (HYSPLIT) model is now operational in many countries, including China and Australia, as the national dispersion forecasting capability. It also serves the NWS in this role. Regis-

tered users can also access HYSPLIT products via the Internet. HYSPLIT is the major product employed in the operations of the Regional Specialized Meteorology Center (RSMC) set up as a joint undertaking of ARL and NCEP under the auspices of the World Meteorological Organization (WMO). The WMO/ RSMC is the source of dispersion products in the event that a pollution plume (in this case, radioactive) crosses international boundaries.

The provision of dispersion forecasts by ARL scientists extends to two specific areas of special relevance - the Nevada Test Site and the Idaho National Engineering and Environment Laboratory. ATL maintains staffs of dedicated dispersion meteorologists at each location, where site-specific models are developed and run using data generated by dedicated regional networks of meteorological sensors.

The Aeronomy Laboratory coordinates an air quality research effort-- the Health of the Atmosphere research. NOAA's Health of the Atmosphere research is focused on the atmospheric science that underlies regional and continental air quality, with the goal of improving our ability to predict and monitor future changes, leading to improved scientific input to decision-making. AL, ARL, CMDL, FSL, PMEL, and ETL participate in the research. The Health of the Atmosphere research goals are:

• Characterize regional ozone episodes - characterize the factors that cause poor air quality in regions of the U.S. where excessive levels of ground-level ozone and fine particle pollution are occurring. In summer 2002, a major field investigation was carried out to characterize air quality in the New England region. Ground-based measurements, ship and aircraft measurements, forecasting, and modeling analyses were applied in the research. Among the processes investigated were the role of nighttime chemistry in the formation of ozone pollution, the role of the sea-breeze/land-breeze circuit in influencing New England's air quality, and the role of the marine boundary layer as a conduit for the movement of pollutants throughout the region.

• Document trends in air quality - help evaluate predicted atmospheric responses to changes in emissions (i.e., the ongoing measurements provided by the AIRMoN and the ozone profiling networks).

• Develop a better understanding of the fundamental science underlying the processes responsible for the formation and distribution of fine particles in the atmosphere to improve the atmospheric predictive capability that links sources of fine particles and their precursors to human exposure and visibility impairment.

In future Health of the Atmosphere research, the OAR Laboratories will integrate their meteorological, chemical, and forecasting expertise to build an assessment and prediction capability for regional air quality that incorporates the influence of multiple-timescale meteorology/climatology. While the ambient levels of pollutants like ozone and fine particles are clearly dependent on pollutant emissions, a large fraction of the variation in those levels is driven by meteorology, both in the short term and longer term. Therefore, the key to assessing both the intended long-term improvements in air quality and the more-episodic variations lies in understanding not only the atmospheric linkages between emissions and concentrations, but also in understanding the coupled chemical and meteorological processes. This "chemical meteorology" research will extend the current program focus on emissions/concentration linkages to include a predictive understanding of the role of synoptic, seasonal/interannual, and longer-term meteorological/climatological changes on the chemistry of the lower atmosphere. Research efforts will also focus on an evaluation and improvement of the tools used to forecast future air quality and the observing systems needed to evaluate their skill.

This approach was used in the summer 2004 New England Air Quality Study, which built on the groundwork laid by the scoping study done as NEAQS 2002. Observations were made from an array of platforms that includes a dozen aircraft, the NOAA research vessel Ronald H. Brown, and several ground sites in New England and Nova Scotia. The research, which is being led by NOAA and the University of New Hampshire and involves several U.S. and international partners, will help provide the solid science to underpin the region's future efforts to improve air quality for its citizens. NEAQS will also help provide the scientific understanding needed for a new air quality forecasting capability that NOAA's Office of Oceanic and Atmospheric Research and National Weather Service are developing in partnership with the Environmental Protection Agency. The forecast guidance was launched in summer 2004 in New England in conjunction with the NEAQS mission.

The Air Quality Research Subcommittee of the Committee on Environment and Natural Resources (CENR) provides interagency collaboration at the U.S. Federal level. NOAA co-leads the AQRS. On the broader international arena, the coordinating body is the North American Research Strategy for Tropospheric Ozone (NARSTO), a tri-lateral public/private partnership focused on ozone and particulate matter research in the U.S., Canada, and Mexico.

ETL uses its suite of remote sensors, including a mobile profiler network, airborne and ground-based ozone Lidars, Doppler Lidar, and supporting turbulence instrumentation to understand and better model the transport, transformation, and fate of primary and secondary pollutants in both rural

and urban environments as well as in complex orography. ETL participated in field programs in FY 2002 designed to develop a deeper understanding of climate variability and source pollutants in the New England region (Atmospheric Investigation, Regional Modeling, Analysis and Prediction (AIRMAP) and NEPS, and to investigate the composition of air masses along the Pacific coast of North America as part of the Intercontinental Transport and Chemical Transformation (ITCT) program. ITCT is a coordinated international research program designed to address the question, "How does the transport of chemicals from one continent influence the air quality in other continents, as well as regional and global climate?" ETL will be deploying a number of lidar systems and wind profiler radars in support of these programs.

GLOBAL DRIFTER PROGRAM

AOML manages the deployment of drifting buoys around the world, deploying some 300 new drifters annually and tracking nearly 700. Using research ships, VOS, and United States Navy aircraft, Global Lagrangian Drifters (GLD) are placed in areas of interest. Once verified operational, they are reported to AOML's Data Assembly Center (DAC). Incoming data from the drifter are then placed on the Global Telecommunications System (GTS) for distribution to meteorological services everywhere. The primary goal of this project is to assemble and provide uniform quality control of SST and surface velocity measurements. These measurements are obtained as part of an international program designed to make this data available in an effort to improve climate prediction. Climate prediction models require accurate estimates of SST to initialize their ocean component. Drifting buoys provide essential ground truth SST data for this purpose. The models also require validation by comparison with independent data sets. Surface velocity measurements are used for this validation.

SOUTHERN HEMISPHERE DRIFTING BUOY PROGRAM

In support of Global Climate Observing System (GCOS) requirements, OAR, in cooperation with NWS, the Office of Global Programs (OGP; housed within OAR), AOML, and the Scripps Institution of Oceanography, maintains a network of approximately 100 meteorological drifting buoys in the Southern Hemisphere. The buoys measure atmospheric pressure at sea-level, air temperature, surface sea water temperature, and surface currents. Observations are obtained through the ARGOS data collection and platform location system on-board the NOAA polar-orbiting satellites. The buoys are a subset of the Global Drifter Program.

The Tropical Atmosphere Ocean/TRIangle Trans-Ocean buoy Network (TAO/TRITON) array consists of approximately 70 Autonomous Temperature Line Acquisition System (ATLAS) and TRITON moorings in the tropical Pacific Ocean, telemetering oceanographic and meteorological data to shore in real-time via the ARGOS satellite system. Designed to improve detection, understanding, and prediction of El Niño, TAO/TRITON is a major component of the El Niño/Southern Oscillation (ENSO) Observing System, the Global Climate Observing System (GCOS), and the Global Ocean Observing System (GOOS). The array is supported primarily by the United States (NOAA) and Japan (JAMSTEC) with contributions from France (IRD) and Taiwan (NTU). The mooring array is maintained by the TAO Project Office located at PMEL in Seattle, Washington, which has responsibility for project management and logistics. The mooring array operations are being transferred to NWS. These buoys provide climate researchers, weather prediction centers, and scientists around the world with real-time data from the tropical Pacific. El Niño (the warm phase of the ENSO cycle) is associated with a disruption of the ocean-atmosphere system in the tropical Pacific and has important consequences for weather around the globe.

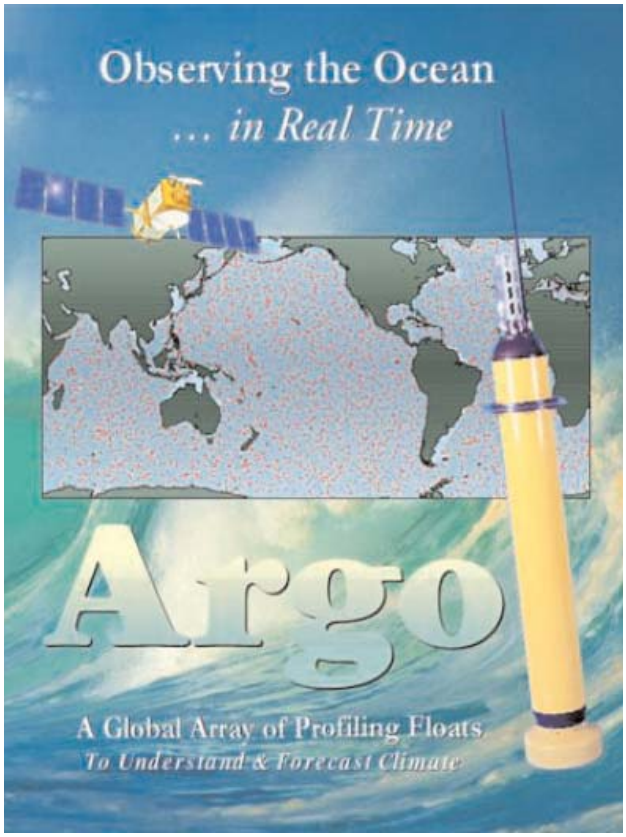
The Pilot Research Moored Array in the Tropical Atlantic (PIRATA) is a project designed as an extension of the TAO array into the Atlantic. The purpose of PIRATA is to study ocean-atmosphere interactions in the tropical Atlantic that are relevant to regional climate variability on seasonal, interannual and longer time scales. It consists of an array of 12 ATLAS moorings similar to those deployed in the Pacific. Planned expansion of the PIRATA array into the hurricane genesis region of the Atlantic will allow for a better understanding of ocean-atmosphere interactions on hurricane development and enhanced predictions of hurricane formation.

ARGO--GLOBAL ARRAY OF PROFILING FLOATS

The ARGO array will deploy a global array of 3,000 profiling floats to better understand and forecast climate. ARGO floats are free-drifting profiling floats that spend most of their life "parked" at 1,000 or 2,000 meters depth, regularly surfacing to make temperature and salinity profile measurements. Observations are made in real-time. As of June 2004, 1250 ARGO floats have been deployed. The Argo array is part of the Global Climate Observing System/Global Ocean Observing System GCOS/ GOOS) and is a major contributor to the WCRP's Climate Variability and Predictability Experiment (CLIVAR) and the Global Ocean Data Assimilation Experiment (GODAE). Along with satellites, ARGO helps initiate the oceanic equivalent of today's operational observing system for the global atmos-

phere.

Ocean Reference Stations. The Ocean Reference Station network is a planned network of 29 operational ocean moorings that measure high quality air-sea fluxes of heat, moisture, and momentum. These in-situ fluxes will then be used to make regional assessments of flux components from numerical weather prediction models and satellites. The network currently has 2 operational moorings; a partnership with the National Science Foundation's ORION program will greatly enhance the capacity of the network.



The National Ocean Service (NOS) monitors, assesses, and forecasts conditions in the coastal and oceanic environment to maintain a healthy, safe, and economically productive coastal and oceanic environment for present and future generations. NOS is the primary civil agency within the Federal government responsible for the health and safety of our Nation's coastal and oceanic environment. Largely through the Tides and Current Program line, NOS acquires water levels, currents, winds, and other physical oceanographic and meteorological data, and distributes these data and circulation predictions as elements of an integrated NOS program to provide a comprehensive science-based suite of information products required by the marine transportation community to ensure safe and efficient marine transportation, including the transport of oil and other hazardous materials. NOS also provides coastal oceanographic and meteorological products required by the National Weather Service (NWS) to meet its short-term weather and forecasting responsibilities, including tsunami and storm surge warnings. NOS manages several observing systems and programs, however three in particular are heavily linked to the capability of NOAA to meet weather and water needs of the nation.

NATIONAL WATER LEVEL OBSERVATION NETWORK (NWLON)

NOS manages the NWLON, 175 stations located along the coasts of the U.S. and the Great Lakes, from which water level data, as well as other oceanographic and meteorological data, are collected and disseminated. NWLON provides a number of NOAA and other Federal programs with data and supporting information, such as the NOAA Nautical Charting Program, NWS Tsunami Warning System, NWS storm surge warning/forecast activities, and the Climate and Global Change Program. An event triggered or manually triggered NWLON modification is now operational that allows emergency "Tsunami Warning" GOES transmissions to NWS when the water level exceeds a specified high/low limit or when the rate of change between the standard 6-minute water level values exceeds a specified value. A similar event triggered modification is also operated for the NWS storm surge warning program when expected elevations are predicted or observed during coastal storms and hurricanes. This capability for high-rate data has recently been enhanced at many stations by the introduction of 6-minute interval GOES transmissions. Although not all NWLON stations are presently equipped with meteorological sensors, an increasing number of stations are each year. Water level and meteorological data are automatically formatted into bulletin format for inclusion into the NOAA AWIPS pipeline.

PHYSICAL OCEANOGRAPHIC REAL-TIME SYSTEM (PORTS®)

PORTS® is a decision support tool which improves the safety and efficiency of maritime commerce and coastal resource management through the integration of real-time environmental observations, forecasts, and other geospatial information. PORTS® measures and disseminates observations and predictions of water levels, currents, salinity, and many meteorological parameters, e.g. winds, barometric pressure, and visibility, needed and requested by the mariner to navigate safely. Highway and railroad bridge mounted "Air Gap" sensors for water level detection are presently being developed and are included in future plans for PORTS®.

The 12 existing PORTS® systems come in a variety of sizes and configurations, each specifically designed to meet local user requirements. PORTS® are partnership programs in which local operating partners fund the installation and operation of the measurement systems. The largest of NOS's existing installations is comprised of over 26 separate instruments. The smallest consists of a single water level gauge and associated oceanographic and meteorological instruments, i.e. winds, barometric pressure, etc. (Figure 3-DOC-21). Regardless of its size, each PORTS® installation provides information that allows shippers and port operators to maximize port throughput while maintaining an adequate margin of safety for the increasingly large vessels visiting United States ports. In addition, prevention of maritime accidents is the most cost effective measure that can be taken to protect fragile coastal ecosystems. One major oil spill, e.g. EXXON VALDEZ, can cost billions of dollars and destroy sensitive marine habitats critical to supporting coastal marine ecosystems. PORTS® provides information to make navigation safer, thus reducing the likelihood of a maritime accident, and also provides the information necessary to mitigate the damages from a spill, should one occur. An extensible PORTS® can be integrated with other marine transportation technologies such as Electronic Chart Display Information Systems (ECDIS) and Vessel Traffic Systems (VTS).

The integration of PORTS® technology and numerical circulation models allows nowcasts and predictions of parameters within the boundaries of the models even at locations where physical measurements are not available. The Chesapeake Bay Oceanographic Forecasting System (CBOFS) is an NOS project that provides forecasts of total water level within the Bay in addition to the astronomical tidal prediction. The New York/New Jersey Harbor nowcast/forecast model came on line in 2003, followed by a Houston/Galveston Bay nowcast/fore-

cast model in 2004. Future operational models will include the St. Johns River, FL and the Great Lakes. Also, ongoing research will enable PORTS® or similar systems to incorporate biological and chemical sensor systems and forecast models as required and integrate the information with circulation measurements to provide information on transports of materials in the ecosystem essential for effective marine resource management and homeland security.

THE NOS CONTINUOUS REAL-TIME MONITORING SYSTEM (CORMS)

CORMS was designed to operate on a 24 hour/7 days a week basis to ensure the accuracy and working status of tide and current observations acquired via the NWLON and PORTS® programs. CORMS improves the overall data quality assurance of real-time measurements, reduces NOAA's potential liability from disseminating inadequate data, and makes the observations more useful for all applications. CORMS ingests real-time data from all field sensors and systems, including the operational nowcast/forecast models, determines data quality, and identifies and communicates the presence of invalid or suspect data to real-time users/customers who rely on the data. CORMS is especially vigilant during storm and tsunami events to ensure the full set of products and services is being disseminated in a timely fashion. An advanced version of this system, CORMS AI, is presently in developmental stages (Figure 3-DOC-22).

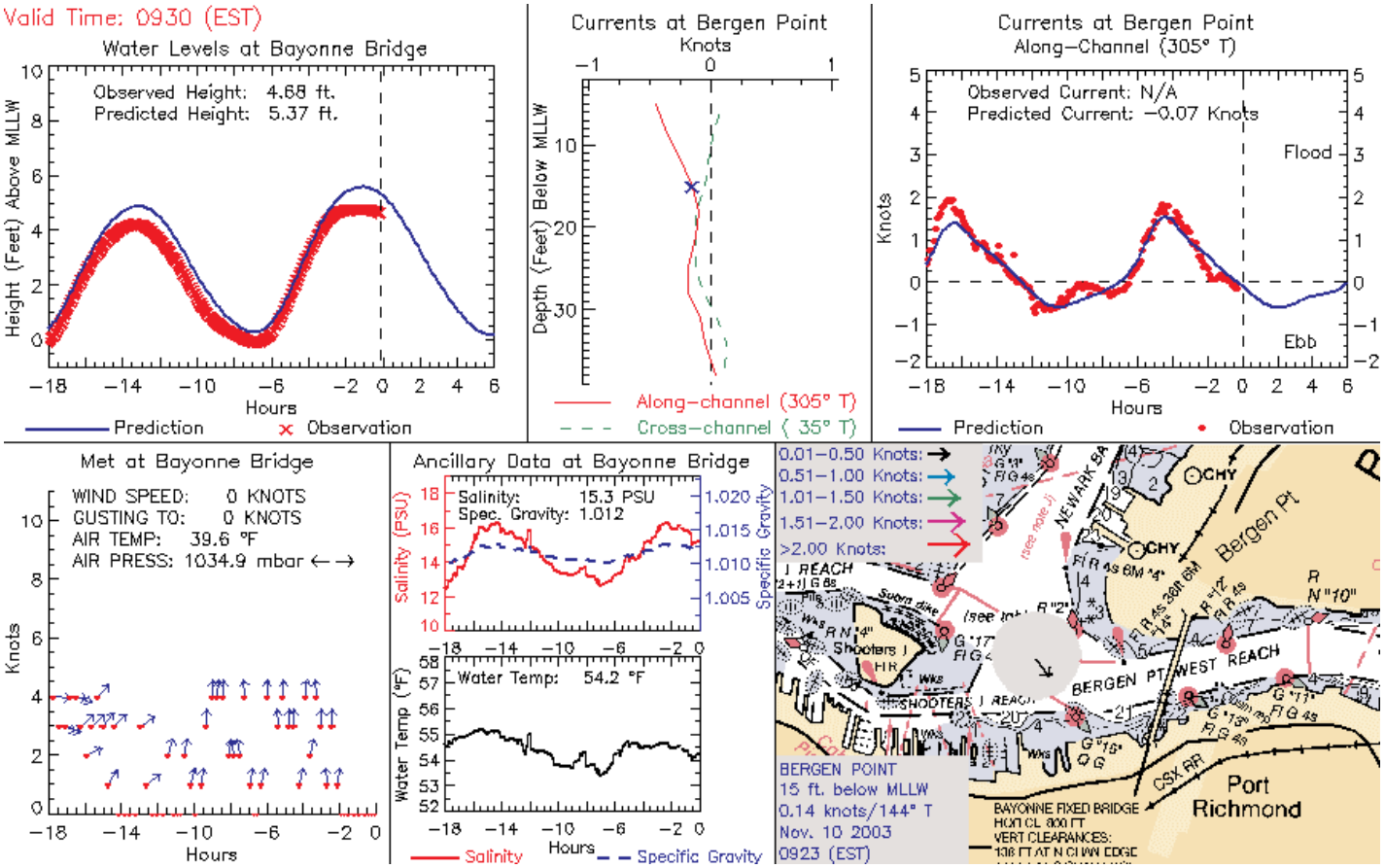


Figure 3-DOC-21. New York/New Jersey PORTS: Bergen Point Composite.

Figure 3-DOC-22. PORTS sites in the New York and New Jersey linked by CORMS.

NOAA Marine and Aviation Operations (NMAO) operates a wide variety of specialized ships and aircraft to support NOAA mission goals. NOAA's ship fleet includes oceanographic and atmospheric research vessels. NOAA's aircraft fleet includes aircraft that collect environmental and geographic data essential to NOAA hurricane and other severe weather and atmospheric research; and aircraft that conduct aerial surveys for hydrologic research for forecasting flooding potential from snow melt.

Figure 3-DOC-24. NOAA Ship KA'IMIMOANA

NOAA SHIPS SUPPORTING METEOROLOGICAL ACTIVITIES

• NOAA Ship RONALD H. BROWN, an oceanographic and atmospheric research platform, is the largest vessel in the NOAA fleet (274 feet). With its instruments and sensors, RONALD H. BROWN (Figure 3-DOC-23) travels worldwide supporting scientific studies to increase our understanding of the world's oceans and climate. An advanced meteorological scientific Doppler radar makes the ship a unique attribute to the research fleet.

• NOAA Ship KA'IMIMOANA (Figure 3-DOC-24) primarily supports the research programs of NOAA's Tropical Atmosphere-Ocean (TAO) Project (real-time data from moored ocean buoys for improved detection, understanding and prediction of El Niño and La Niña). These research programs are designed to improve our understanding of the role of the tropical ocean in the world's climate. The ship deploys, recovers, and services deep sea moorings that measure ocean currents, ocean temperatures, and atmospheric variables, throughout the equatorial Pacific Ocean. In addition to data from these moorings, the ship measures upper ocean currents, surface salinity, carbon dioxide content, and takes upper air atmospheric soundings while underway.

The RONALD H. BROWN and KA'IMIMOANA annually support the Tropical Atmospheric Ocean (TAO) Array by servicing approximately 60 ATLAS and current meter moorings in the central and eastern equatorial Pacific.

In FY 2006, the RONALD H. BROWN will conduct the African Monsoon Multidisciplinary Analysis study to improve understanding of the West African monsoon and its influence both on the regional environment as well as its role in Atlantic tropical cyclone development.

Also in FY 2006, the RONALD H. BROWN will continue work on the NOAA Climate Forcing and Air Quality Programs by conducting a combined Air Quality and Climate Research Study to better characterize marine/continental chemical and meteorological processes to assess their impact on air quality in Texas and radiative forcing of climate. As in previous studies off the New England region, this may include use of NOAA

Figure 3-DOC-23. NOAA Ship RONALD H. BROWN

and other aircraft for data collection.

A new initiative this year will be the sharing of weather data obtained by certain NOAA ships with NWS coastal Weather Forecast Offices (WFO). What follows is an excerpt from a February 14, 2005, article in the *NWS Focus* that explains this new partnership further:

NOAA Agencies Join Forces to Test Collaborative Communications Concept

The NOAA Office of Marine and Aviation Operations (NMAO) and the NOAA National Weather Service (NWS) Southern Region are working together to test a new communications project designed to serve the interest of both line offices. In an excellent example of inter-agency cooperation, NMAO and the NWS have devised an information sharing system to benefit NOAA ships and NWS coastal Weather Forecast Offices (WFO). "Our ships are always in need of up-to-date marine forecasts," said Rear Admiral Richard R. Behn, NOAA Director, Marine and Aviation Operations Centers. "In turn, the WFOs are always searching for real time weather data from sea because they don't have buoys everywhere."

NWS Southern Region Marine Services Meteorologist Melinda Bailey says 13 Southern Region WFOs, from Brownsville, Texas to Jacksonville, Fla., will participate in the test project. "Each of the NOAA ships will have a file with a complete list of phone numbers and the names of key personnel in our coastal WFOs. Our specialists can then provide any type of specialized forecast that may be needed." In return, the forecast offices will have access to the NMAO's Ship Tracker software so they will know where the ships are. The forecasters will also have a list of the ship's port, cellular and satellite phone numbers. National Weather Service Southern Region forecast offices participating in the project include Brownsville, Corpus Christi and Houston, Texas; Lake Charles and New Orleans, La.; Mobile, Ala.; San Juan, Puerto Rico; and, Tallahassee, Tampa, Key West, Miami, Melbourne and Jacksonville, Fla.

NOAA's Office Marine and Aviation Operations currently has 18 ships plying the waters of the Pacific and Atlantic Oceans and the Gulf of Mexico. The fleet includes ships that provide hydrographic survey, oceanographic, atmospheric and fisheries research in support of the National Oceanic and Atmospheric Administration mission to predict and understand the Earth's environment and conserve and manage coastal and marine resources.

The test is scheduled to run through the end of year, at which time the results will be evaluated. "If we find the program works well from both the standpoint of the Office of Marine and Aviation Operations and the National Weather Service, we will expand it to include all coastal offices in the United Sates," added Behn.

Another advancement this FY was the development of the NOAA Shipboard Environmental Data Acquisition System (SEAS). SEAS will provide real-time meteorological and oceanographic data to NOAA users from ships at sea through the use of INMARSAT C satellite data transmissions. Along with ships of the NOAA fleet, meteorological observations made onboard merchant vessels of the NOAA voluntary observing ships (VOS) program, are a substantial component of global weather forecasting and climate studies. SEAS equipped vessels are an essential part of the NOAA VOS program and provide as many as 80,000 observations per year. SEAS records weather information in the World Meteorological Organization (WMO) MET transmission format (BBXX) and transmits it in real-time via satellite. All of NOAA's research ships carry SEAS equipment, with the exception of the two small Class 5 vessels (COBB and RUDE). Most of NOAA's ships submit at least one SEAS report a day and some submit up to eight reports a day (one every three hours).

NOAA AIRCRAFT SUPPORTING METEOROLOGICAL ACTIVITIES

NOAA aircraft support a broad range of meteorological activities and projects with its fleet of aircraft based at MacDill Air Force Base in Tampa, Florida. Four of its14 aircraft are dedicated to this purpose throughout the year, providing valuable information to NOAA and the nation.

The NOAA Gulfstream, G-IV(SP) (N49RF), provides scientists with a platform for the investigation of processes in the upper troposphere and lower stratosphere (Figure 3-DOC-25). With a ceiling of 45,000 ft, the G-IV is a critical tool for obtaining the data necessary to improve hurricane track forecasts and for research leading to improvements in hurricane intensity forecasts. The G-IV is also being used for air chemistry studies where a high altitude capability is required. In 2005, hurricane researchers studying the role of Saharan dust on tropical storm development and intensity will also use this aircraft.

Figure 3-DOC-25. NOAA Gulfstream G-IVSP

The NOAA G-IV annually supports Hurricane Synoptic Surveillance missions where the aircraft flies in the environment surrounding the storm at a high altitude releasing GPS dropson-

des at pre-selected locations. The data from these vertical atmospheric soundings are transmitted from the aircraft to the NCEP computer site where they are incorporated into the hurricane computer models to improve hurricane track forecasts. The dropsonde (Figure 3-DOC-26) directly measures temperature, pressure, and humidity as it falls through the atmosphere to the surface, and computes wind speed and wind direction using a full-up GPS receiver (which is new in 2005). Recent estimates of the improvement in hurricane track predictions utilizing this aircraft and dropsonde are between 20 and 30 percent, resulting in a savings of $10

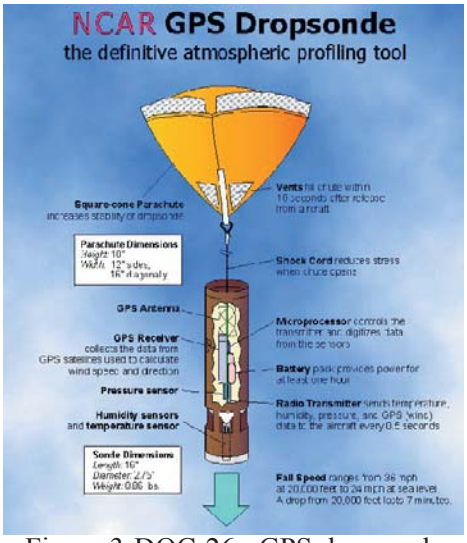


Figure 3-DOC-26. GPS dropsonde

million or more per hurricane in warning and preparedness costs.

The NOAA G-IV also annually supports the Winter Storms Reconnaissance Program in an effort to improve forecasts released 24 to 96 hours before winter storms in the U.S. This aircraft, in conjunction with the Air Force Reserve's WC-130s, utilize the GPS dropsondes to collect data on developing severe winter storms over the Pacific Ocean that will seriously impact the continental U.S. and Alaska. During one month of the two-month season, both aircraft operate in tandem, one from Alaska and the other from Hawaii, to collect data both north and south of the jet stream simultaneously. General improvement in forecast accuracy of up to 20 percent has already been seen, and even higher percentage improvements on individually targeted events have been realized from this program. Typically, during the final month of the program, the NOAA G-IV operates independently from either the base in Alaska or Hawaii as the case may dictate.

A recent additional mission for the G-IV was the support of the THORPEX Regional Campaign (TReC). THORPEX is a global atmospheric research program designed to accelerate improvements in the accuracy of 1 to 14-day weather forecasts for the benefit of society and the economy. TReC was a regional study that took place in the North Atlantic, and the G-IV contributed with a month-long program, operating from bases in Newfoundland and Ireland.

NOAA's Aeronomy Lab, located in Boulder, CO, is presently expanding its air chemistry capabilities on the G-IV beyond just ozone measurements with the addition of a proton transfer reaction mass spectrometer (PTR_MS). The PTR_MS provides in-situ measurements of volatile organic compounds (VOCs) and an instrument to measure carbon monoxide (CO). Beyond just their dedicated research, lab scientists also hope to piggyback on missions during the 2005 hurricane season.

Also during the 2005 hurricane season, scientists from NOAA's Hurricane Research Division will be utilizing the G-IV in an investigation of the Saharan dust layer over the Atlantic. The Saharan Air Layer (SAL) has been investigated fairly extensively during the past several decades, but its role in influencing Atlantic tropical cyclone activity has not been thoroughly examined. This experiment is designed to utilize the G-IV to study the mechanisms by which the SAL's embedded mineral dust, thermodynamic properties, and low-level wind surge affect Atlantic tropical cyclone genesis and intensity change.

NOAA's atmospheric and oceanographic research, as well as its reconnaissance operations, are supported by two WP-3D Lockheed Orion aircraft (N42RF and N43RF) which carry a full array of state-of-the-art environmental research instrumentation (Figure 3-DOC-27). The aircraft research and navigation systems provide detailed spatial and temporal observations of a wide range of atmospheric and oceanic parameters. NOAA's Aircraft Operations Center (AOC) develops and calibrates specialized instruments, integrates user-supplied instrumentation into its automated data recording systems, and processes and

Figure 3-DOC-27. NOAA WP-3 Orion

analyzes data sets collected during various field programs.

The AOC WP-3D aircraft, while executing the complex patterns for hurricane research, also provided storm data to the National Hurricane Center (NHC) in near real-time, transmitting flight level data, GPS dropsonde messages, as well as radar images via its multiple aircraft-satellite data links. With the Stepped Frequency Microwave Radiometers (SFMR) coming online operational during FY 2004, increasing emphasis is being placed on utilizing the NOAA WP-3Ds to map the surface wind fields in and around hurricanes and tropical storms. Real-time surface wind speed maps are critical to providing more accurate forecasts of the locations of hurricane and storm force winds.

The AOC aircraft also augment the Air Force Reserve reconnaissance aircraft during particularly active storm periods when tasking requirements exceed their available resources.

Each year, one of the NOAA WP-3Ds participates in a Hurricane Awareness Tour targeting, alternately, the Gulf and East coast regions of the U.S., those areas that are most vulnerable to land-falling storms. This educational outreach effort is directed at both-middle-grade school children, the age group most likely to see, learn and convey a message home, as well as the general public. These tours are operated in concert with the participation of officials from NHC, the Red Cross, FEMA and other local and state emergency management personnel. This is becoming an increasingly more popular and successful venture as coastal populations grow and the threat of an increasing number of storms place more people in harm's way.

The NOAA WP-3Ds annually support both a summer and winter operation in support of a NESDIS satellite validation program. Operating in regions of high winds and heavy precipitation, one of the WP-3Ds, equipped with microwave scatterometers and radiometers provide underflight validation of NOAA satellite QuickScat and WindSat sensed ocean surface wind vectors. Traditional venues for these operations have been Alaska or Newfoundland in the winter and the Atlantic and Caribbean regions during the summer hurricane season.

Every other year one of the NOAA WP-3Ds participates in an intensive air chemistry program, usually in concert with a number of other Federal agencies and universities. During July 2004, N42RF took part in a multi-platform experiment based from Portsmouth, NH. This New England Air Quality Study (NEAQS) employed a number of aircraft, ground stations, and also the NOAA Ship Ronald H. Brown. The NEAQS project area covered the entire northeastern corridor from Cleveland east and north into Canada. Packed completely with an impressive array of in-situ chemical samplers and three instrument pods mounted beneath the wings of the aircraft, measurements of a wide range of chemical constituents were made at low levels over the urban and rural landmass as well as the marine boundary layer. Additionally, atmospheric profiles were made from the surface to the maximum altitude capability of the aircraft (~25,000 ft). This work will continue in the summer of 2006, during a similar experiment in the Houston area. It should be no surprise that the experiment will be called the Texas Air Quality Study, or TexAQS.

During the winter of 2005, one of the NOAA WP-3Ds completed the Atmospheric Rivers (AR) Project over the Pacific northeast of the Hawaiian Islands. As part of the NOAA weather-climate program, this project focused on documenting the flow of moisture moving in a northeasterly direction toward the U.S. mainland - measurements that are critical to both the global water cycle and to storm prediction.

A study of the pre-cold-frontal low-level jet (LLJ) that precedes land-falling extra-tropical storms approaching the West Coast of the U.S. is scheduled for next winter. This LLJ plays a critical role in the transport of water vapor into the coastal mountains where orographic enhancement of precipitation can generate disastrous floods.

A NOAA AC690A Turbo Commander (N53RF) and a NOAA AC-500 Shrike (N51RF) have been utilized frequently over past years to conduct important snow surveys in the northern and western continental U.S., Alaska, and southern Canada. (N53RF will be retired during FY 2005 and be replaced by a refurbished JetProp Commander - N45RF) (Figure 3-DOC-28). During these survey flights, snow water-equivalent estimates are obtained and sent to the National Operational Hydrologic Remote Sensing Center (NOHRSC) up to three times a day from each aircraft, and after further processing the information is distributed to NWS field offices within five minutes of receipt from each aircraft. These data are used by the NWS to forecast river levels and potential flood events resulting from snowmelt water runoff. Hydroelectric power interests and other water supply managers also use the data to regulate water storage and delivery.

Figure 3-DOC-28. NOAA JetProp Commander - N45RF.